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ABSTRACT

Results of a study of women's access to higher education in Kenya, especially in the areas of science and mathematics, are presented. Forty secondary school teachers completed a questionnaire, and women students studying science and science-based subjects were interviewed. Enrollment at the elementary, secondary, and college levels and the questionnaire and interview responses were examined. Five major school factors were considered: sex-role stereotyping, previous academic achievement, instructional methods, facilities, and teachers. Attitudes toward science were assessed, including self-confidence, career interests, and expectations. The influence of socioeconomic status and parents' education and background was also investigated. It was found that women were underrepresented in higher education and in science and mathematics education and that they also underachieved in these fields. It is suggested that the structure of the school curriculum, its content, and methods influence the enrollment and achievement of females in science. Twelve recommendations to increase the participation of female students in science education are offered; most of these recommendations concern the secondary level. Data are provided on enrollment trends for males and females by educational level, womens' majors, and sex differences in science examinations. (SW)

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A STUDY OF WOMEN'S ACCESS TO HIGHER
EDUCATION IN KENYA WITH A SPECIAL
REFERENCE TO MATHEMATICS AND SCIENCE
EDUCATION

10/14/203

By

Professor G.S. Eshiwani

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A STUDY OF WOMEN'S ACCESS TO HIGHER EDUCATION
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George S. Eshiwani

1. Introduction:

Women's struggle to participate fully in most educational systems has had a long and often bitter history. In the third world countries the struggle has barely started. Statistics on women in these countries show that the percentage of women 15 years old and over who have completed secondary school education varies between 2 to 15 per cent. Perhaps the most alarming statistic is the proportion of women who have had opportunity to study science and mathematics. In his recent book "The Missing Half", Kelly (1981) has shown that in tertiary education women are under-represented in science compared to other subjects. In Africa, for example, the average number of men for every woman studying natural science is 10; in engineering the number is 70 while in medicine the number is six. In all tertiary education there are seven men for every woman. This implies that the percentage of women at tertiary level in Africa is less than 15 per cent. Comparison of individual countries show even a grimmer picture. Women are under 5 per cent of science students in Saudi Arabia, Zaire, the Congo and in Togo. Parallel data in other African countries is either non-existent or is lying in some official documents waiting to be analysed. This study was partly in response to this need for information on the representation of Kenyan women in science and mathematics education.

Related to the question of representation is the question of achievement among girls in science and mathematics education. In the Western world there is abundant literature which shows that in general girls under-achieve in mathematics and science compared to boys (see Comber and Keeves, 1973; Kelly, 1978; Husen, 1967). However, in the third world countries, especially in Africa, literature on this phenomenon is scarce. Assuming that the phenomenon exists, then one must consider the factors that cause performance differences between boys and girls in order to propose intervention strategies.

Factors that have been found to be responsible for under-achievement in science and mathematics among girls have been grouped into two broad categories: those which stress biology in terms of innate characteristics, and those which stress environmental causes, usually described in terms of socialization.

The second category includes factors directly related to the school system. Walden and Walkerdine (1982) have observed that "school is the main site for the teaching and learning of science and mathematics". The school is therefore in many ways responsible for the different treatment and experience of boys and girls in the science and mathematics classrooms. This implies that the education system of any given country may very well be responsible for sowing the seeds of differential achievement in its very structure (see Stanworth, 1961; Delamont, 1976; and Deen 1978).

The education system of a country expresses consciously or unconsciously the wider organisation of the culture of that country. This means that under-representation and under-achievement in science and mathematics among girls may be explained on the basis of the culture in which the girls are brought up.

The study reported here examines these factors in relation to achievement in science and mathematics among females in Kenya. Although reference is made to the biological factors in various sections of this report, the main focus of the study was on the environmental factors. Reasons for this focus were few but significant. First, it has not been conclusively shown that girls who perform poorly in mathematics and science have a lower academic ability than their male counterparts who achieve high in mathematics. Secondly, girls of high ability differ from boys of the same ability with respect to mathematical/scientific interests, course-taking and career interests. This suggests that environmental factors play a major role in sex differences in science and mathematics. Thirdly, even if it was proved that sex differences in mathematics was due to an inherited trait, we would still have to consider the environmental factors because heredity and environment are interrelated.

2. Purpose of the Study

The purpose of this study was to investigate the women's access to higher education in Kenya, especially in the area of science and mathematics education. Women's representation and achievement in science and mathematics education was examined with a view to suggest intervention strategies where they warranted. Specifically, the study attempted to answer the following questions:

1. What were the enrolment and drop-out rates among boys and girls in the primary school, secondary school and at University from 1964 to 1980?
2. What were the enrolment rates in Forms V and VI science classes and in science based faculties at University for the years 1970 - 1980?

3. What is the nature and extent of sex differences in the learning of mathematics and science, the study of mathematics and science, the aptitude for the study and learning of mathematics and science?
4. What factors in the lives or education of students at secondary school influence the learning or study of mathematics and science and the pursuit of careers which require mathematical/scientific skills or competency?

3. Why Bother?

Some of the studies referred to in the above paragraphs show that women are generally under-represented and exhibit poor performance in science and mathematics. This has several implications for the education and economic well-being of women.

First, most girls encounter formal science education for the first time (and last) time in secondary school. If they drop out of science at this stage they are unlikely to take it up again. This means that those girls who either drop science at this level or fail, not only do they self-select themselves out of the path to jobs in quantitative fields per se, but they delimit their career options and advancement opportunities in many fields. Kenya is short of technicians and technologists. She can therefore ill afford to see half of her population missing in science and mathematics education.

Secondly, it is important that women are encouraged to study science and mathematics so that they have access to professions which depend on scientific training, since members of these professions control many aspects in present-day technology. Science is changing society, and these changes should not be directed exclusively by men. As many women as possible should have sufficient scientific understanding to enable them to take full and informed part in current debates on such issues as energy resources and environmental pollution.

Thirdly, when girls leave school they operate in an environment that is full of machinery and labour-saving devices. If they have not had an exposure to science they become passive consumers of technology which they do not understand. More adequate scientific education for girls could combat this situation.

Finally, mathematics is a critical filter for science education and careers related to it. For future employment of women, planners should know the extent to which science is studied by girls and how they achieve in it.

The study of women's representation and achievement in science education must be seen in the overall context of women's access to education. It was therefore necessary to examine women's participation in the formal education, since formal education is closely related, to the economic status. At the time of this study, less than one fifth of those employed in the formal sector in Kenya were women. Only 16 per cent of those holding jobs classified as high and middle level were women, and most (69 per cent) of this small group were working as nurses, teachers and secretaries. Less than 15% of those working in the quantitative fields were women (see Eshiwani, 1981).

4. Methodology:

Data for this study was collected in three phases over a period of 16 months.

The first phase consisted of a thorough study of enrolment records from the Ministry of Basic Education, Ministry of Higher Education, the University of Nairobi and Kenyatta University College. We considered the enrolment records for males and females at primary level, secondary level and University level respectively. At secondary level we analysed the number of girls who had enrolled in science classes at Form VI level in selected schools. For University data, we were particularly interested to find out the enrolment rates by sex in various faculties and especially in those faculties that were science-based. This phase took a much longer period than had been anticipated due to sporadic closure of the University during the 1980/81 academic year. In certain cases we found the records from the Ministries of Education contradictory, particularly when we considered the question of repetition and drop-out. It took considerable time to reconcile the figures.

The second phase of the study consisted of administering a questionnaire to Head teachers in 40 secondary schools with Sixth Form. These secondary schools were selected from schools in Nairobi, Central Province and Western Province. The questionnaire was handed to the Head teacher personally by me and was left behind to be completed and mailed to me at a later date. This was due to the nature of the information which we wanted. Some of the school data we wanted from the Heads required some research to be done by the Head Teachers. Such information included school facilities for science and mathematics teaching; the provision, qualification and experience of science teachers, the ratio of male to female teachers in the school and in the science department; drop-out rates and reasons for these drop-outs; and details of school performance in science subjects and in mathematics at A-level.

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This last variable i.e. school achievement in science and mathematics was studied in greater detail by analysing the performance of boys and girls at O-level and at A-level in all science subjects and mathematics for 1979, 1980 and 1981 respectively. This data was analysed for boys and girls in all secondary schools which had Form VI classes.

During the second phase of data collection we also administered a questionnaire to female students in Forms VI in the same schools we administered the Heads questionnaire. The questionnaire which was completed by girls sought information on the background of the students,, their academic as well as career aspirations and expectations, their attitudes towards science e.t.c. Both the Heads questionnaire and the students questionnaire can be obtained from the Bureau of Educational Research.

The third phase consisted of interview schedules with selected women students studying science and science-based subjects at the University of Nairobi and Kenyatta University College.

5. RESULTS AND DISCUSSION

This section is divided into three major parts. The first part deals with enrolment in the formal educational system. Enrolment is discussed at three levels: Primary School, Secondary School and University. Related to the whole question of enrolment is wastage or drop-out rates in the system.

The second part of the section deals with achievement in science and mathematics both at O-level and at A-level. In order to assess the general academic ability between boys and girls, achievement data in other subjects has also been analysed.

The third and final part of the section discusses factors that influence the learning or study of mathematics and science among Kenyan girls.

It is not possible to appreciate the results of this study and the conclusions that we have drawn without taking into account the Kenya Educational system.

The Kenya Educational system consists of three levels:* Basic Education, Secondary Education and University Education. Basic Education consists of Pre-school and Primary Education. The latter takes seven years culminating in a national examination - the Certificate of Primary Education (C.P.E.). The OPE is a certificate of attainment and is awarded to all the pupils who complete seven years of education and sit the prescribed examination. Selection for secondary school is based on the performance in this examination.

*Note: From 1984 the structure of the system of education will change from 7:4:2:3 to 8:4:4

Only 30 per cent of those who take the CPE get the opportunity to go to secondary school. During the last decade the expansion at the primary school level has been enormous. In 1981 there were over 10,260 primary schools in Kenya with a total population of slightly over 4 million children and over 102,464 teachers. This means that one quarter of Kenya's total population is in the primary school.

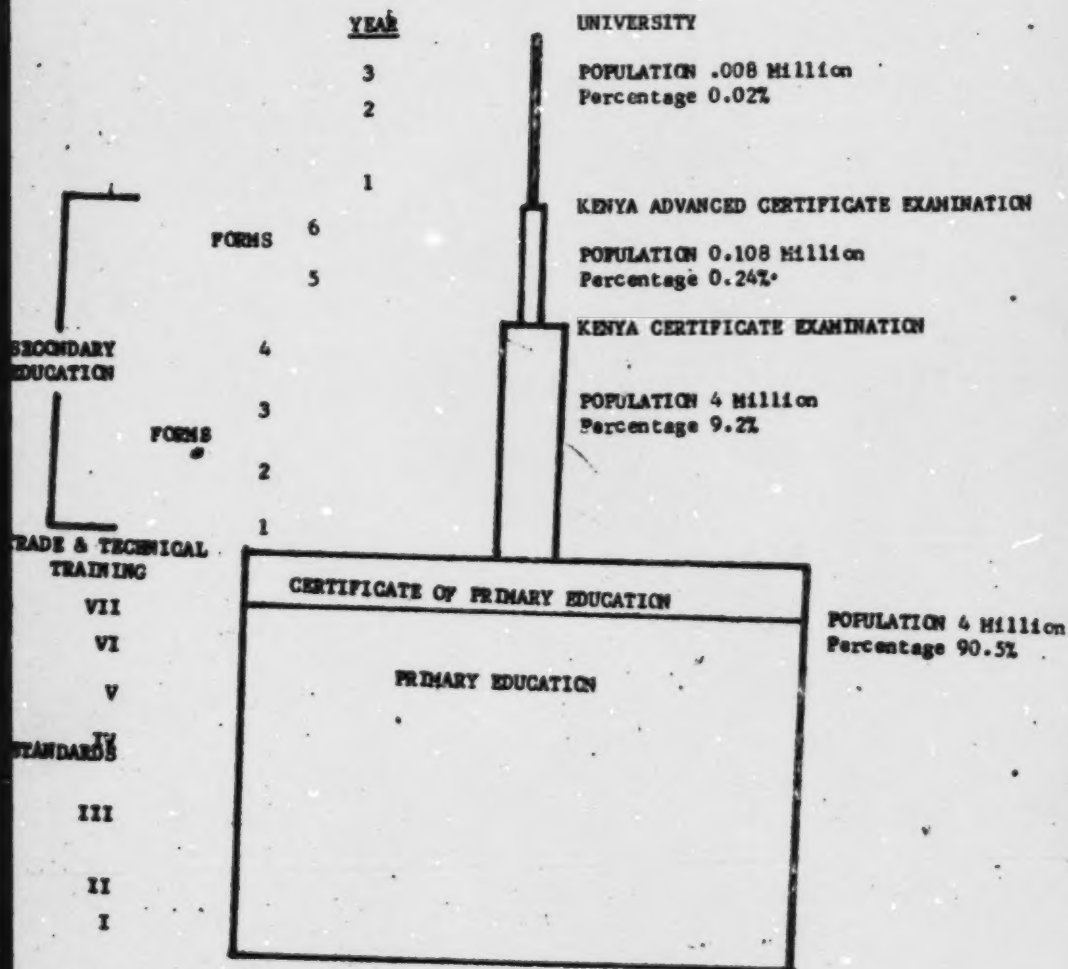
The secondary school education is a six year year programme (Form I - VI) taken in two stages. The first four years (Forms I - IV) lead to the Kenya Certificate of Education (Equivalent to GCE - O-level). At the end of the second year of the secondary school, there is an optional examination, the Kenya Junior Secondary Examination (KJSE), which is taken by students in the Harambee* and Private Secondary Schools in an attempt to enter Government maintained Secondary Schools. The Kenya Certificate of Education (KCE) is used to select those to proceed into the second stage of the secondary education - the A-level segment. This segment is divided into specialised Science and Arts streams. The number of secondary schools is much smaller compared to the number of primary schools quoted above. For example, in 1980 there were 1502 secondary schools, of which 557 were Government maintained, 64 were Government assisted, 990 were Harambee schools. and 259 were private schools which were established and managed by individuals or Church organizations. While majority of the private and Harambee schools were co-educational (Mixed), the majority of the Government aided schools were not. The total number of students at secondary school in 1980 was 410,626, and the number of teachers was 15,916.

The University education in Kenya is even more competitive than the secondary school education. In 1979, 11,032 candidates sat for the Kenya Advanced Certificate Examination (A-level Examination). Out of this number only 2,611 were admitted to the University leaving out 8,421 prospective University students, a staggering 77 per cent.

These statistics show that the structure of education in Kenya is a pyramid with a very high attrition rates at the end of seventh year of the primary education, fourth year and sixth year respectively of the secondary education. Figure 1 is an illustration of the structure in 1980.

*Harambee Secondary Schools are Community schools established and managed on self-help basis.

They out-number the Government maintained schools in the ratio 2:1, but follow the same Curriculum as Government maintained schools.



NOTE:

The chart does not take account of the annual wastage or stagnation.

Fig. 1

5.1 Women Representation in Education

5.1.1 Representation at the Primary School Level

Although this study was essentially concerned with the access of women to higher education, I found it necessary to examine the enrolment of girls at the primary school level in order to explain some of the secondary school data.

Table I shows the percentage of girls at the primary school level from 1963 to 1980.

TABLE I
PERCENTAGE OF GIRLS IN PRIMARY SCHOOLS, 1963 - 1980

Year	Total Number of Pupils	Number of girls	Percentage of girls
1963	891,553	304,829	34
1964	1,014,719	357,084	35
1965	1,010,889	379,393	36
1966	1,043,416	379,539	39
1967	1,133,179	443,384	40
1968	1,209,680	464,650	41
1969	1,282,297	519,470	41
1970	1,427,589	591,282	43
1971	1,525,496	644,491	43
1972	1,675,919	719,299	44
1973	1,816,017	790,904	45
1974	2,205,678	1,214,347	45
1975	2,881,155	1,319,654	46
1976	2,894,991	1,340,493	46
1977	2,971,239	1,387,429	47
1978	2,994,991	1,494,500	47
1979	3,698,246	1,744,500	47.2
1980	3,931,500	-	-

Source: Ministry of Education Reports
Central Bureau of Statistics.

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From ~~Figure 2~~ we see that since independence girls' primary school attendance has increased at a faster rate than boys', enabling girls to approach equality in enrolments. In 1963 girls accounted for 34 per cent of primary enrolment. By 1976 female enrolment constituted 46 per cent of total registration at this level. In terms of absolute numbers female primary enrolments increased from over 0.3 million girls in 1963 to 1.7 girls in 1979. Despite this high rate of enrolment, the overall proportion of girls attending primary school in Kenya falls short of the national proportion of women to men. These disparities cannot be explained on the basis of unequal school opportunities for boys and girls. Primary school education in Kenya is co-educational and therefore all children have an equal chance of going to school. Moreover, since 1974 school fees has been abolished at primary school level, thus making it possible for all children to attend school. What factors then cause low educational attainment among girls at primary school level? Mbilinyi (1969)* has identified four major factors in her study in Tanzania as follows:-

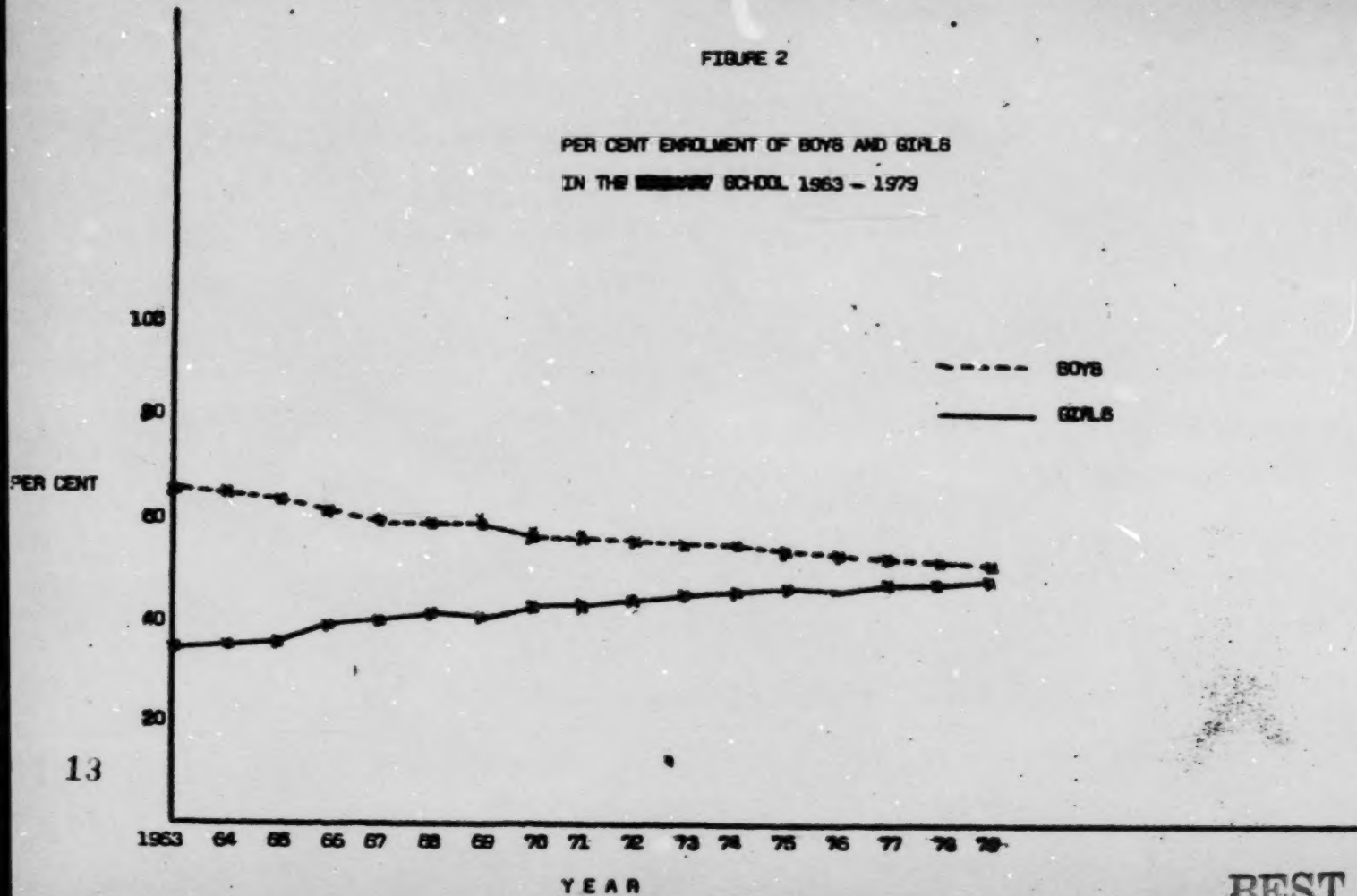
- (a) School Costs.
- (b) The need for domestic assistance of daughters.
- (c) Traditional views towards the proper role of women.
- (d) The 'misconduct' of some female school leavers.

Female enrolment patterns in primary schools in Kenya suggest that when confronted with constraints of limited opportunities or resources for primary schooling, parents have generally favoured the education of male children. Preference for investment in schooling for boys may relate to the patrilineal descent systems in which inheritance passes through the male line and in which sons retain responsibility for their parents as they grow older while daughters are incorporated into their husbands' families. The perceived link between education and employment, in an economic system in which males have had better prospects for wage jobs in the formal sector may have provided an additional economic considerations in educating sons ahead of daughters. Moreover, when there are overriding family chores like looking after young children or cooking for the family, it is usually the girls that are taken out of school to perform these duties.

*Mbilinyi, Majorie: The Education of Girls in Tanzania
Institute of Education University of
Dar es Salaam 1969 PP 71-72

FIGURE 2

PER CENT ENROLMENT OF BOYS AND GIRLS
IN THE ~~PRIMARY~~ SCHOOL 1963 - 1979



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There seems to be a high correlation between opportunities for female primary education and regional economic development. The regions with most employment opportunities and greater agricultural activity, especially of cash crops, are also the regions of greatest educational progress and proportionately greater participation of women in primary education. Table II shows the percentage of women enrolment at primary school by Province. Central Province and Nairobi have the highest percentage of female enrolment while North Eastern and Coast have the lowest female enrolment.

In order to gain a greater insight into the problem of low female enrolment in the two Provinces mentioned above we carried out limited interviews with selected University students from these areas. We found that the access to primary schools for girls was blocked by several factors. First, there was prejudice against girls going to school, especially by parents who were worried about their daughters becoming pregnant or coming into contact with boys from areas outside their clans. Secondly, there was a strong parental concern that discipline within the school was not as tight as it was within the home. This was especially emphasized among the Maasai. This concern has far-reaching implications in the nomadic areas of Kenya where boarding schools have been established for girls. If the parents cannot trust the schools with respect to discipline and supervision of their daughters, then they are likely to be less willing to entrust these girls to schools that have to keep them for a period of three months, leave alone a year.

Some of our interviewees told us that in those areas where there were low female enrolments at primary school level, there were early marriages for girls, often arranged by parents. In contrast, we were told that in those areas where there was a high proportion of girls attending primary school, one major parental motivation was bride price. The more education the girls received the greater the bride price. All these are social conflicts which must be resolved to enable as many girls as possible to enter the primary school.

Enrolment by class by sex was also examined in relation to the total population of children at specific age levels. Figures 3 and 4 show diagrammatically the enrolment ratios of the two sexes in 1979. It is interesting that if one considers the proportion of pupils attending school in each class, there is no significant differences between boys and girls. The only differences worth mentioning do occur in standard seven and in Form IV. These are examination classes. Repetition is a common phenomenon in these classes. Thus we find more pupils in these classes than in the preceding classes. From the two figures, it is evident that more boys repeat Standard seven than girls and more girls repeat Form IV than boys. 15

TABLE II
PRIMARY SCHOOL FEMALE ENROLMENT BY PROVINCE AS PERCENTAGE
OF TOTAL ENROLMENT

YEAR	CENTRAL	COAST	EASTERN	NAIROBI	R. VALLEY	NYANZA	WESTERN	N. EASTERN
1966	43	35	39	44	34	33	40	15
1967	44	34	40	45	35	35	39	16
1968	45	34	40	46	36	36	40	16
1969	45	35	40	45	37	37	42	15
1970	46	35	42	46	38	37	42	15
1971	47	35	43	46	38	38	42	16
1972	47	36	44	47	40	40	43	16
1973	48	36	44	47	41	40	44	19
1975	49	38	47	48	45	44	46	21
1976	49	38	48	48	45	45	47	23
1977	50	39	48	48	46	-	47	25

Source: Annual Census of Schools

Fig. 3 NATIONAL FEMALE ENROLMENT - 1979

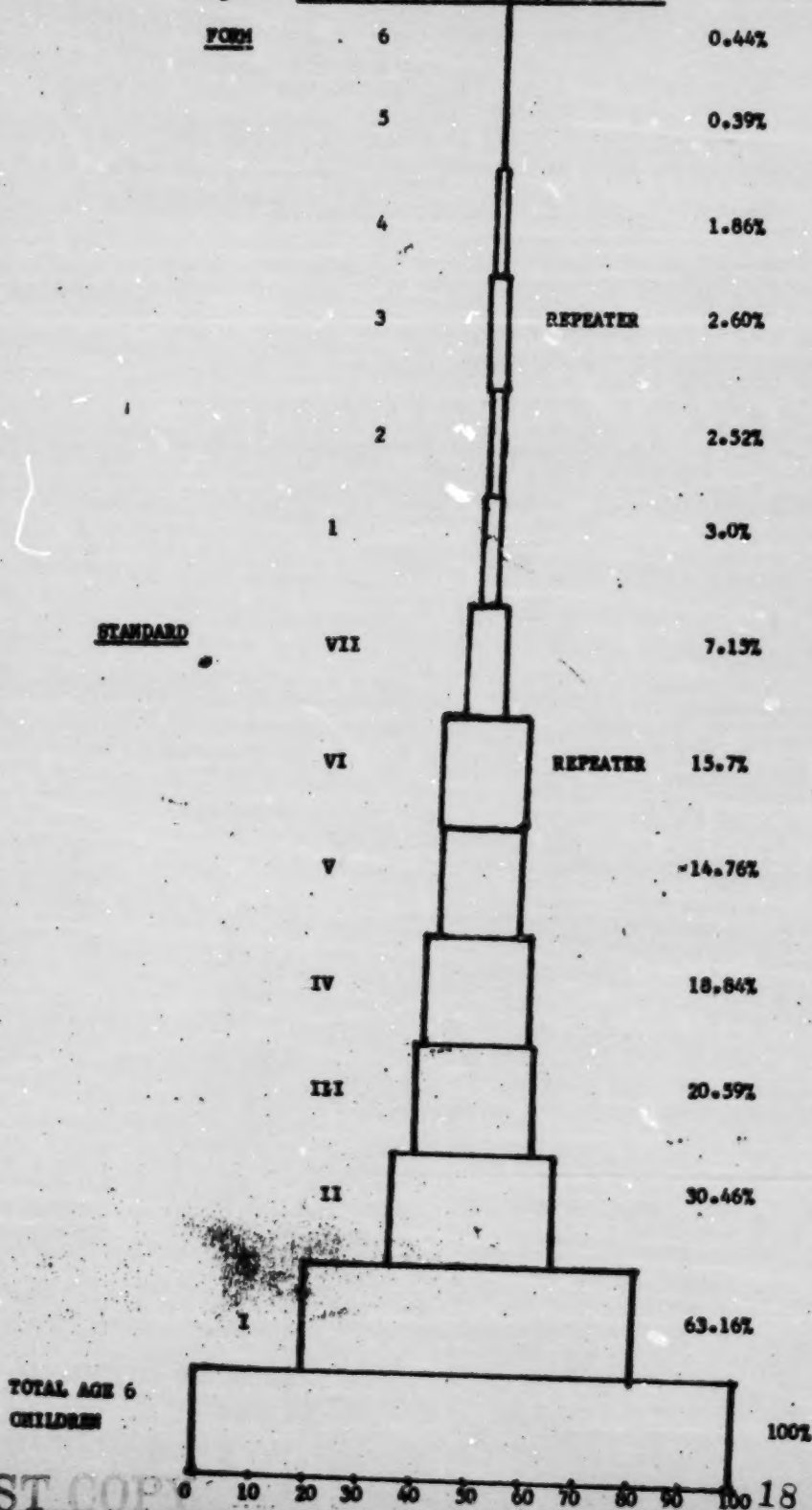
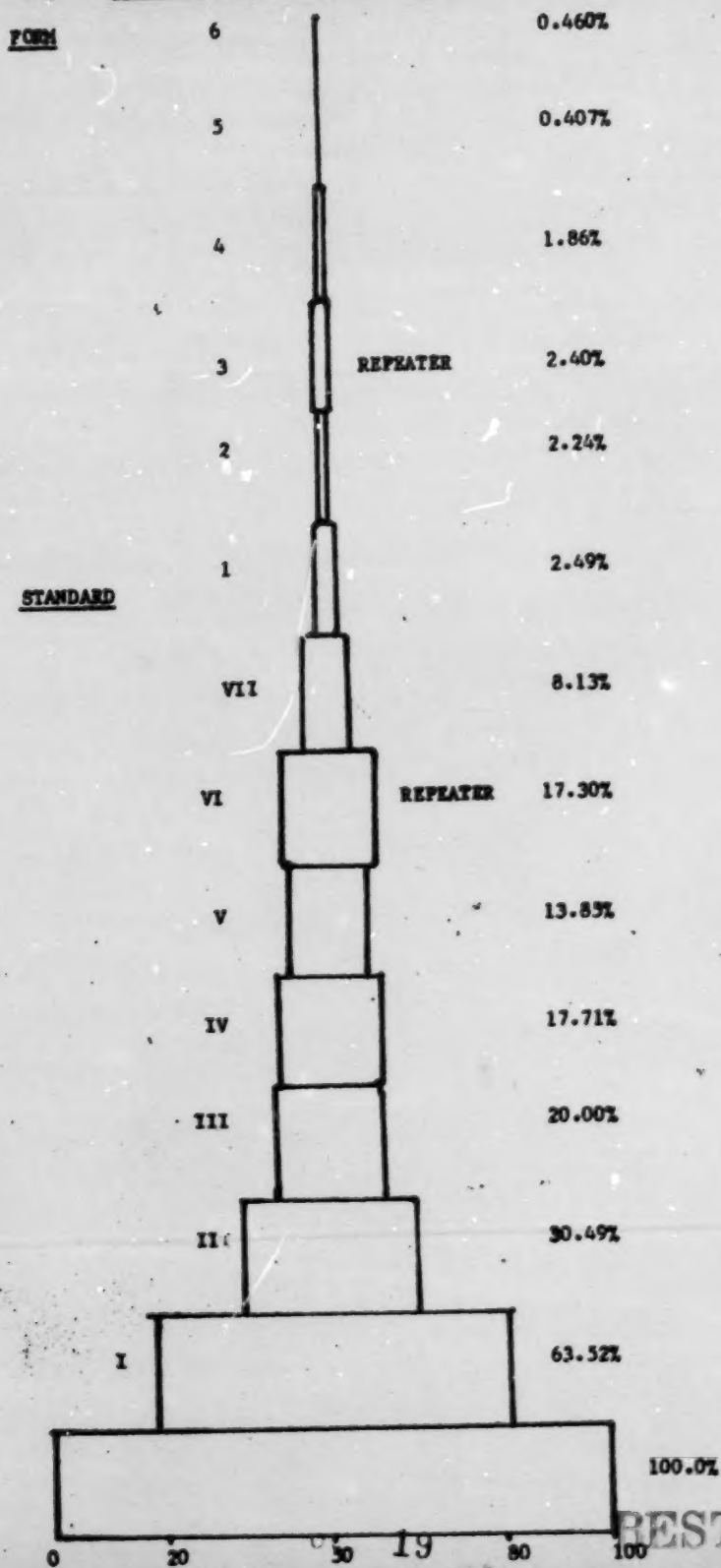


Fig. 4. NATIONAL MALE ENROLMENT 1979



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5.1.2 Female Enrolment in the Secondary School

Table III shows female enrolment in secondary schools from 1963-1979. Although the numbers of women attending secondary school have increased considerably since independence, the rise has not been sufficient to close the gap between female and male enrolments (see Figure 5). Between 1964 and 1971 the proportion of girls in secondary school in Forms I-IV actually declined from 32 per cent in 1963 to a record low of 25 per cent in 1967. Since 1973 women's representation has improved such that in 1977 it rose to 40 per cent of the enrolment in Forms I through IV. Similarly between 1963 and 1971 women's registration in Forms V-VI initially decreased from 23 per cent in 1963 to 22 per cent in 1970. From 1971 it has increased from 23 per cent to 28 per cent in 1978.

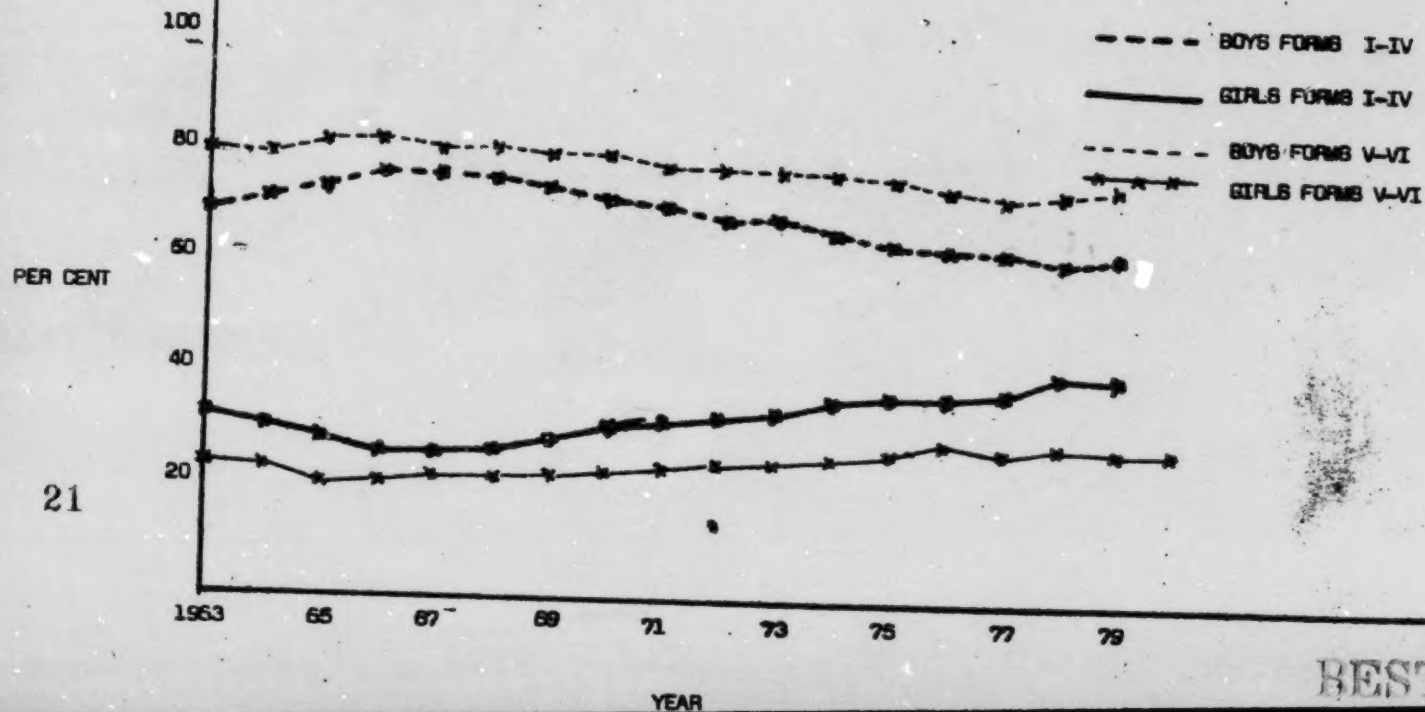
TABLE III

FEMALE ENROLMENT IN SECONDARY SCHOOLS
IN KENYA: 1963-1979

YEAR	NUMBER	PER CENT FORMS I-IV	PER CENT FORMS V-VI
1963	9,567	32	23
1964	10,710	30	23
1965	13,256	28	20
1966	16,391	26	20
1967	22,387	25	21
1968	26,159	26	21
1969	32,150	28	22
1970	37,526	30	22
1971	42,743	31	23
1972	50,615	32	24
1973	57,543	33	24
1974	67,111	35	25
1975	81,259	36	26
1976	103,605	37	28
1977	122,758	38	27
1978	144,723	40	28
1979	154,047	39	27

FIGURE 5

PERCENTAGE ENROLMENT OF BOYS
AND GIRLS IN FORMS I-IV AND V-VI
1963 - 1979



One major conclusion that can be drawn from Table III and Figure 5 is that the proportion of girls enrolled at secondary school has not increased at the same rate as that at primary school level. Subsequently women are significantly under-represented at the secondary school level in Kenya. Reasons for this imbalance between boys and girls at secondary school are many and familiar. Unlike the primary education, secondary school in Kenya is not co-educational. Since the colonial times the trend has been to have separate schools for boys and girls. This may not be itself a bad idea, except that the number of boys' schools far exceeds the number of girls' schools.

Before we discuss the distribution of aided schools by sex, it should be pointed out that aided schools provide a higher quality of education at lower costs than unaided schools. Males have consistently had an advantage in the distribution of aided secondary schools. In 1977 there were 200 aided secondary schools for boys compared 107 aided schools for girls and 65 with co-educational status. This trend has persisted into 1980s. Table IV shows that in 1977 a higher proportion of girls' schools (79%) were boarding institutions as compared with 43 per cent of the boys'. These figures have far-reaching implications with respect to the accessibility of women to higher education. First, the fact that there are fewer aided secondary schools for women than men implies that educational opportunities for women at secondary school level are much more limited than those of men. Secondly, the fact that the number of boarding secondary schools for girls is almost twice that of boys implies that fewer girls can actually afford to go to aided secondary schools. This is because boarding schools usually charge higher fees.

We observed in Table III that there has been a rise in the proportion of females enrolled in secondary schools from 37,526, in 1970 to 154,847 in 1979, a rise of more than 150 per cent.

TABLE IV
DISTRIBUTION OF AIDED SECONDARY SCHOOLS
BY PROVINCE AND SEX 1977

Type of School	Boarding Schools			Day Schools		
Province	Boys	Girls	Mixed	Boys	Girls	Mixed
CENTRAL	19	28	7	29	-	15
COAST	7	4	3	6	2	5
NAIROBI	4	3	-	10	8	1
EASTERN	15	17	1	24	4	5
N. EASTERN	4	1	-	-	-	-
NYANZA	7	11	-	29	4	3
R. VALLEY	13	11	6	4	1	12
WESTERN	17	9	-	12	4	6
TOTAL	66	84	17	114	23	48

TABLE V
NUMBER OF STREAMS IN AIDED SCHOOLS IN FORMS
I-IV BY PROVINCE AND SEX (1977)

Type of School	Boarding Schools			Day Schools		
Province	Boys	Girls	Mixed	Boys	Girls	Mixed
CENTRAL	57	39	14	35	-	16
COAST	14	5	4	12	7	9
NAIROBI	17	8	-	31	23	3
EASTERN	31	26	4	36	5	5
N. EASTERN	4	1	-	-	-	-
NYANZA	14	16	-	37	6	3
R. VALLEY	25	16	12	8	1	20
WESTERN	44	17	-	12	4	6
TOTAL	206	136	34	171	46	62

Source: Ministry of Education.

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This rise has come primarily through an increase in the number of females attending unaided schools. These female students are at a disadvantage with regard to the quality of their schooling compared to their male counterparts. This in turn affects the girls' performance in the terminal examinations which are taken at the end of Form IV. Because the O-level examinations determine entrance to higher education, career training programmes and job opportunities, it means that girls are potentially disadvantaged with respect to higher education and job placement.

In recent years the Kenya Government has emphasized science education especially in the second cycle of the secondary school (Forms V-VI) and at the University. A study of the curriculum options in the Sixth Form schools reveals that most of the places available to girls are in the Arts subjects like history, geography, religious studies *e.t.c.* Boys have proportionately greater access to schools offering courses in sciences and mathematics. Whereas the number of Arts streams for boys and girls have been nearly equal over the past few years, the proportion of the science streams has been heavily skewed towards boys. There are about five science streams for boys to one science for girls. This imbalance means that the chances of girls studying science or science-related subjects are very limited. The situation is made worse by the fact that there are no strong science programmes in most girls secondary schools; and in most unaided schools, where enrolment of girls is quite high, no science programmes are offered. It is therefore not surprising that the few science places that are available to girls in Forms V and VI are not fully utilised (see Table VI). Where these places are filled, it is usually with weak candidates, especially in Physics and Mathematics.

Another area of concern in women's education at the secondary school level is their access to technical and vocational education. None of the technical and vocational secondary schools admits female students. This is an imbalance that can no longer be defended by educational planners.

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TABLE VI
ENROLMENT IN VARIOUS SUBJECTS IN 11 GIRLS' SCHOOLS
IN FORM VI (1976)

SCHOOL	NUMBER OF PLACES	NUMBER ENROLLED	MATHS	PHYSICS	NUMBER TAKING CHEMISTRY	BIOLOGY
Alliance Girls	50	50	57	17	49	42
Highlands	40	40	26	10	32	36
Kabare	30	12	8	--	10	11
Kenya High	30	22	8	16	22	20
Kaaga	30	25	10	7	25	25
Limuru	30	15	11	3	14	13
Lugulu	30	22	6	13	13	20
Ngiya	30	21	21	12	21	21
Pangani	30	11	8	10	11	6
State House Road	30	5	1	5	5	5
Tum Tum	30	23	13	6	23	19
TOTALS	380	246	195	94	225	218

Source: Ministry of Higher Education

5.1.3. Female Enrolment at University Level

The data reported here strictly concerns the number of University students enrolled at the University of Nairobi and its constituent Kenyatta University College. There are many Kenyan University students studying in Foreign countries like India, Canada and United Kingdom. No effort was made to obtain data on these students since it was felt that the proportion of Kenyan women studying abroad was negligible.

In 1973, 15 per cent of the students at the University of Nairobi were women. In her paper entitled "The Education of Women Since Independence", Krystall observed that these women were enrolled primarily in the Faculty of Arts, in the Faculty of Education (Arts) and in the department of Advanced Nursing. Women were significantly under-represented in the Faculties which require science combinations for admission. We set out to examine women enrolment at University with these observations in mind. What follows is an analysis of women enrolment at the University of Nairobi for the years 1970 to 1980 in various Faculties.

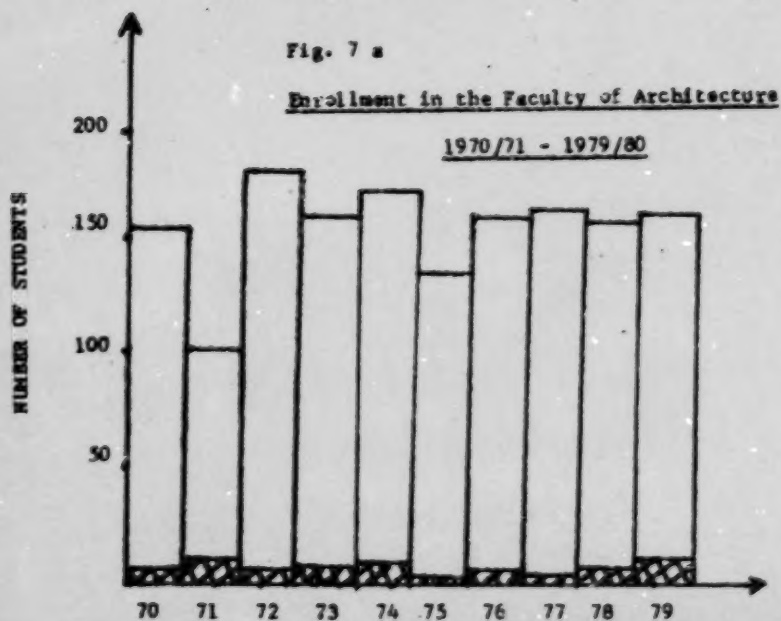
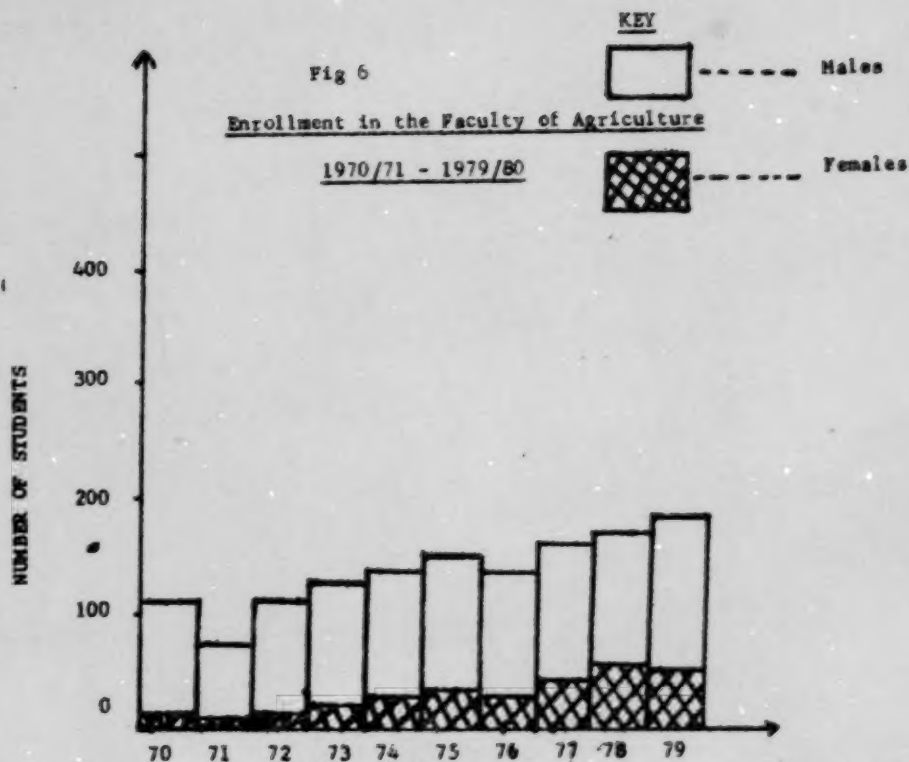
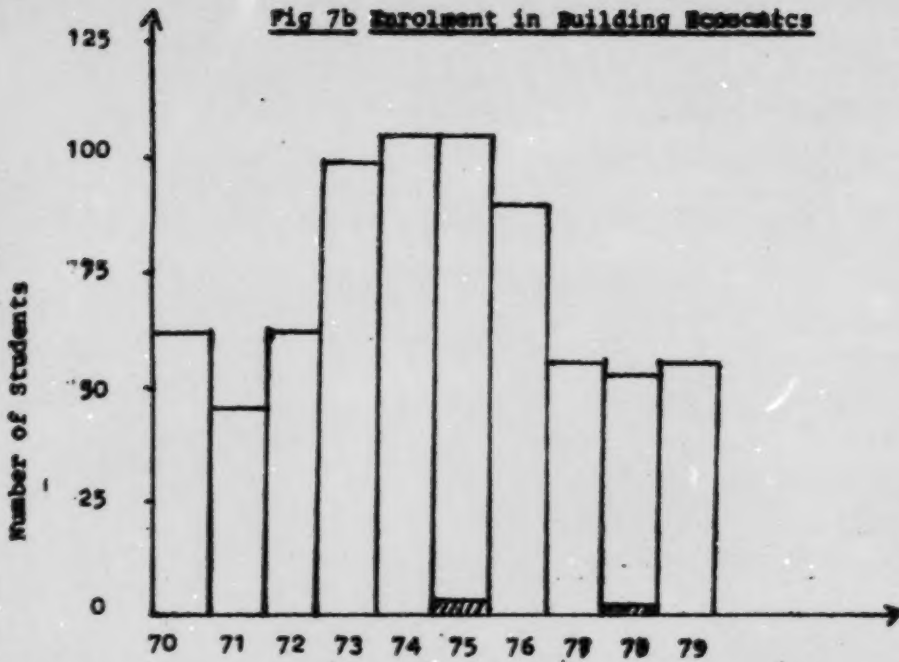
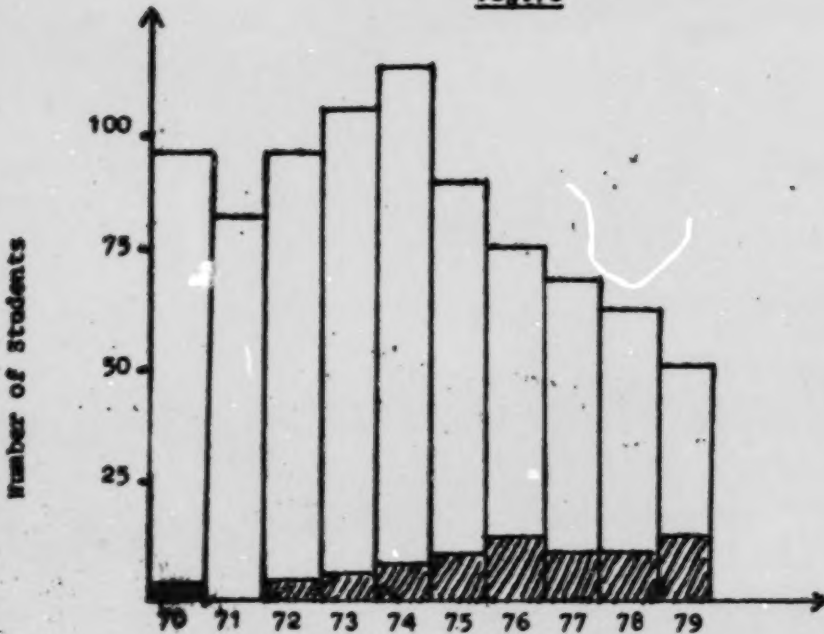


Fig 7b Enrolment in Building Economics



Enrolment in Land Economics 1970/71-1979/80

Fig.7c



(a) Female Enrolment in the Faculty of Agriculture

Figure 6 shows the enrolment pattern in the Faculty of Agriculture from 1970 to 1980. It indicates that the number of female students has risen gradually from 5 students in 1971 to 82 in 1980. An increase of 32 per cent is significant. However, in terms of absolute numbers male students far outnumber female students by a ratio of 3 : 1. There are two major factors which seem to have contributed to more girls wanting to study agriculture. First, Egerton College gave a lead in admitting girls to study agricultural subjects leading to a diploma certificate. This might have had a positive influence on the girls still at school to study agriculture. Secondly, the subject combinations required for agriculture include biology, chemistry and geography. A study of subject choices among the science female students in Forms V and VI shows that biology and chemistry are the most preferred subjects.

(b) Female Enrolment in the Faculty of Architecture

Figure 7a shows the proportion of female students to male students in the Faculty of Architecture for the years 1970 to 1980. During that period, architecture was mainly a male faculty. The highest number of women students to enroll in this faculty was 9 in 1979/80, 5.4 per cent of the total enrolment that year. This is understandable since one of the admission requirements into the faculty of architecture is a principal pass in mathematics. Secondly, architecture is considered by the Kenya Society to be a masculine profession. Because of this, girls who could very well study architecture shy away from it. This is despite the fact that in several Kenyan ethnic communities it was women and not men who used to build houses.

The same pattern of enrolment in architecture is to be found in the departments of building economics and land economics - Figure 7b and 7c respectively. The highest number of women students enrolled in the department of building economics has been 2 out of 100 students. The enrolment of female students in the departments of land economics has shown a slight improvement from zero per cent to 21 per cent in 1980. As in the case of architecture, these two courses do not generate much interest among girls at school. While the mathematics requirement could be a major barrier to girls wishing to enroll in the two departments, the main cause of the low enrolment is lack of motivation on the part of the female students.

Fig 8

Enrollment in commerce
1970/71 - 1979/80

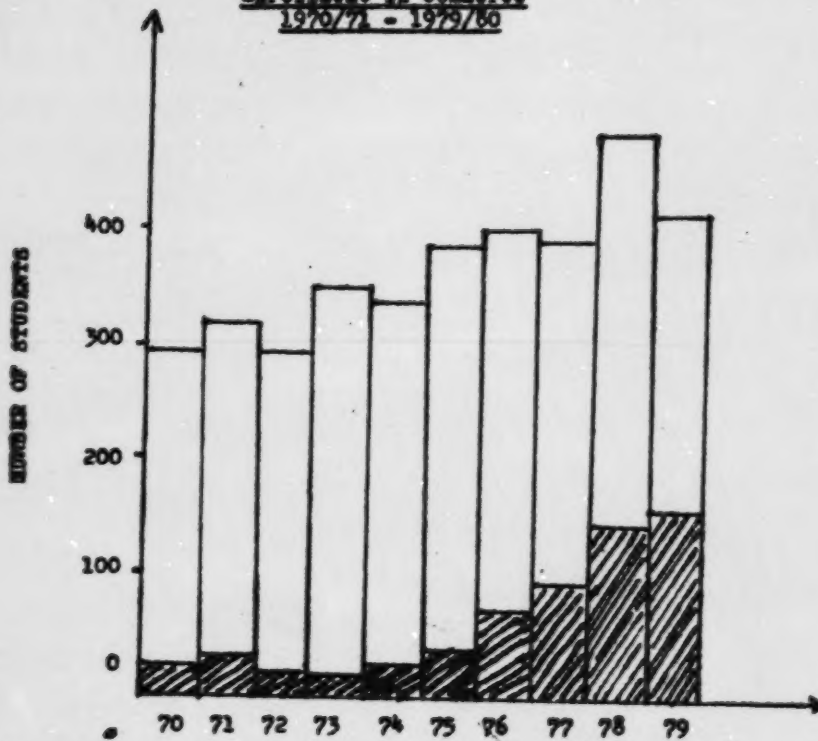
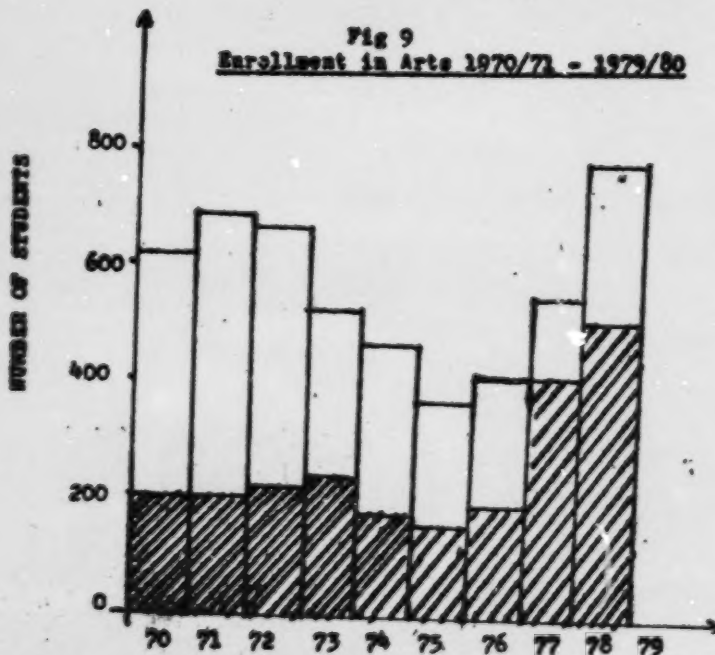


Fig 9

Enrollment in Arts 1970/71 - 1979/80



(c) Female Enrolment in the Faculty of Commerce

Figure 8 shows the proportion of women to men students in the faculty of Commerce. Although there has been a steady rise in the number of women students, (12 students in 1970 to 162 students in 1980) their proportion in comparison to the number of men students has been very low. For example in 1980, there were 162 women students out of a total of 589 students in the faculty. This means that the highest percentage women have attained in their enrolment in the faculty of commerce is 28 per cent. One of the main reasons for this low enrolment is the lack of women candidates with A-level passes in mathematics. Courses in the Commerce which have a component of economics and statistics tend to put off students who feel that they are weak in mathematics.

(d) Female Enrolment in the Faculty of Arts

The pattern of enrolment in the Faculty of Arts is shown in Figure 9. It is generally believed by educators that the Faculty of Arts is predominantly a women's faculty. The statistics in Figure 9 do not support this belief. The highest number of women students in the faculty of Arts was recorded in 1979 when there were 502 women students out of a total of 1305 students. This number accounted for 39 per cent of the total number of the under-graduate Arts' students. The reasons for the low enrolment of women compared to men in the faculty of arts are not easy to discover. As already noted the number of female candidates offering Arts subjects at A-level is comparable to the number of male candidates. Therefore the low enrolment among the female students at the University suggests that the performance of female candidates at A-level is inferior to the performance of male candidates. This is compounded by a high drop out rate among the females due to pregnancies either in Form VI or prior to joining the University.

(e) Female Enrolment in the Faculty of Engineering

Figure 10 shows the proportion of female enrolment in the Faculty of Engineering at the University of Nairobi for the past ten years. Female representation in this faculty is negligible. Out of an average of 400 students enrolled each year from 1970 - 1977, the average number of female students was three, less than one per cent. In 1979/80 the number of females improved to 12 and thus accounted for 2.2. per cent. What are the reasons for this dismal female enrolment? First, engineering requires mathematics and physics. These are the subjects that are least subscribed to by girls in A-level schools, and where the girls offer the subjects, they perform very poorly as we shall see later in this report.

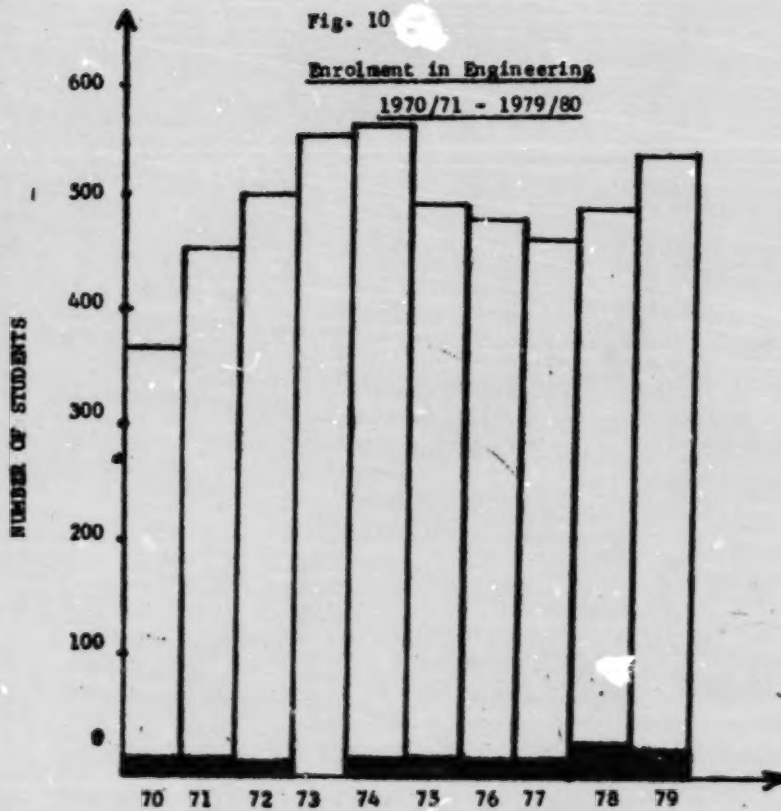
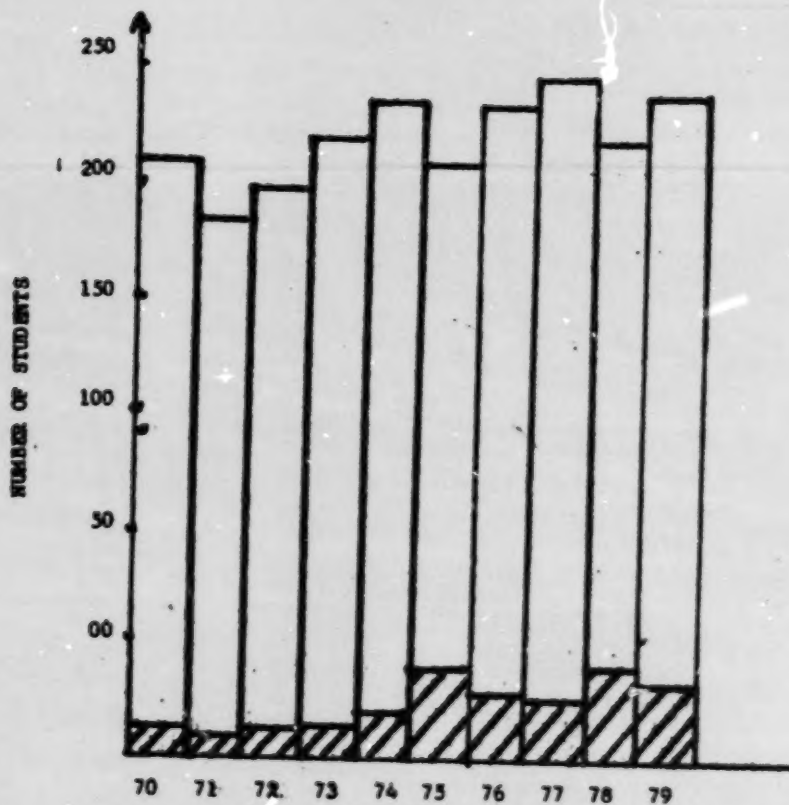
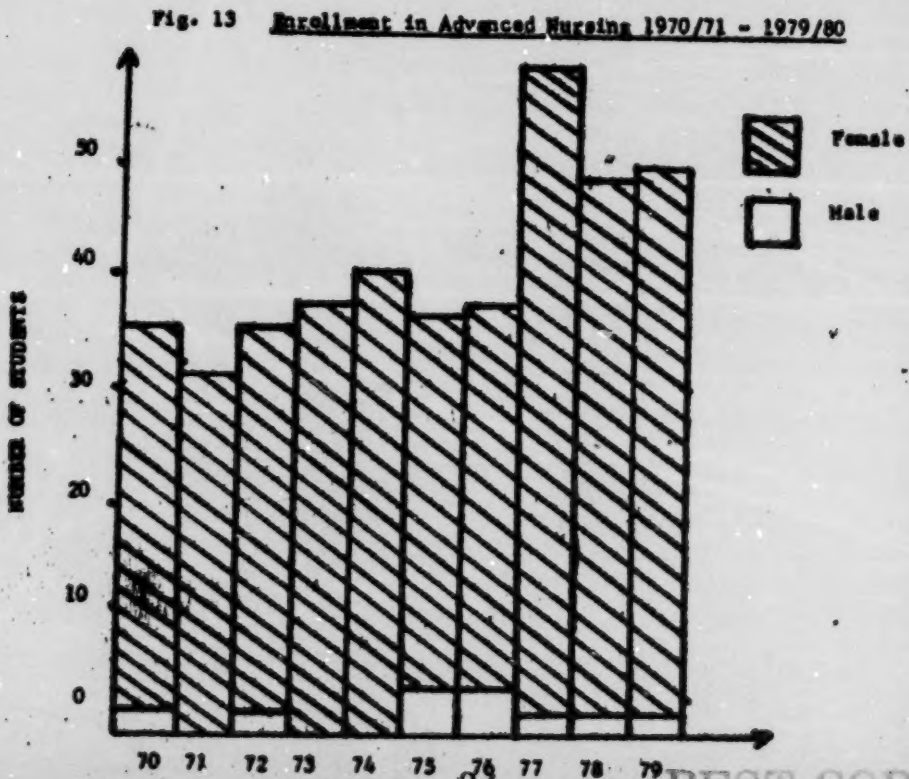
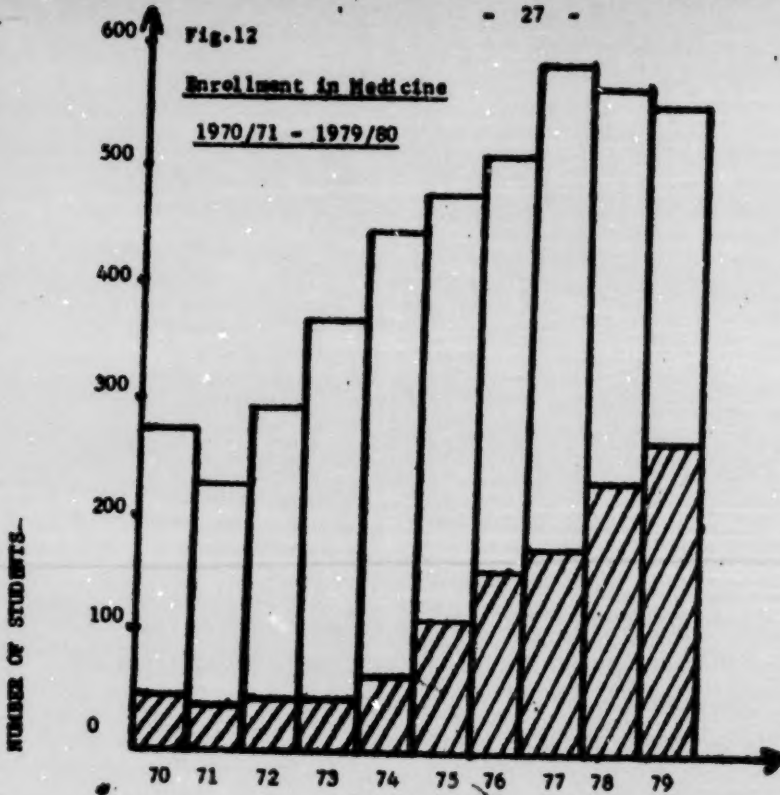


Fig. 11

Female Enrolment in the Faculty of Veterinary Medicine





Secondly, engineering is wrongly regarded by many school girls (and boys) as a profession that requires a lot of strength and endurance. Given their tender hands, girls cannot imagine that they can become engineers. In short they have no aspiration to become engineers. This lack of motivation for engineering can in turn be traced to the societal expectations of women roles and their occupations.

In a recent editorial (January, 14, 1982) The Standard noted that to a large extent women who obtain education and have to work in paid employment, seek jobs in professions that are considered "feminine". The editor argued that this could not be due to the physical requirement for the technical jobs, because in Kenya, women do more manual work than men. It is the attitude women have towards the technical professions like engineering that have led to the low enrolment in these fields. This negative attitude is a product of men's expectations of women's roles in society. If we accept the premise that faster development of the country will come through women's acquisition of technical skills, then the attitude towards technical fields such as engineering by women and society must change. How this change will be brought about is the main challenge facing science educators.

(f) Female Enrolment in the Faculty of Medicine and Veterinary Science and Advanced Nursing

Female enrolment in the Faculty of Medicine has shown an interesting pattern compared to Engineering. The number of women students in this faculty has increased steadily from over 40 students in 1970/71 to over 250 students in 1979/80. This is well illustrated in Figure 12. The 1980 number represents 31.5 per cent of undergraduate medical students. This rather healthy representation has been due to the fact that most of the girls at A-level who offer science, take Biology and Chemistry. The two subjects are required for admission into the faculty of medicine. Since the Faculty attracts some of the best candidates at A-level, it means that girls perform very well in Biology and Chemistry. Unlike engineering medicine is regarded by the Kenyan society in general and by the Kenyan women in particular to have a feminine touch. Few eyebrows will be raised when a woman is introduced as a medical doctor but a woman engineer is regarded by most people not to be feminine.

The femininity of the medical profession is well illustrated by the enrolment in the Advanced Nursing Course. Figure 13 shows that apart from a springling of few males, the department of Advanced Nursing has been dominated by female students.

The close relationship between medicine and veterinary medicine would imply that the female enrolment in both faculties is the same. A comparison of Figure 11 and 12 shows that this is not the case. While a significant rise in the number of women students was realised in the Faculty of Medicine, this was not so in the Faculty of Veterinary Medicine. The highest female enrolment in this Faculty during the 1970/80 decade was in 1979, when women accounted for 13 per cent of the total undergraduate students in the Faculty. The reason for this low enrolment is to be found in the societal expectations with regard to the role of women. In general women are not expected to deal with matters concerning livestock or domesticated animals.

(g) Female Enrolment in the Faculty of Law

Female enrolment in the Faculty of Law has gradually increased from 20 students in 1970 to 75 students in 1980. This was out of a total of 120 students and 150 students respectively. The implication here is that the female enrolment is steadily approaching parity with respect to the enrolment of male students. Figure 14 clearly illustrates this and indicates that law as a profession is liked by females. The recent appointment of women to high office in the legal profession will encourage more girls to study law.

(h) Female Enrolment in the Faculty of Education

Figures 15 and 16 represent female enrolment in the Faculty of Education, Arts and Science respectively. The female enrolment among the Arts students increased steadily up to nearly 50 per cent of the total number of students in 1975, but started to decrease proportionately from 1976 to 1980. Among the science education students the female representation was much lower than in the Arts stream. While there was a sharp increase in the male education science students (see Figure 16), the proportion of the female enrolment remained almost constant from 1972 to 1980. The actual number of female education science students was hardly above 30. Of particular significance and worth noting was the 1977/78 academic year which recorded the highest number of education students studying science - 226. Out of this number only 19 were women, a representation of 8.4. per cent.

Although teaching is supposed to be a popular profession among the females, these statistics clearly show that for a long time to come the number of women science teachers in Kenya will continue to be very small. This has an adverse effect on science education for girls in two ways. First, the majority of teachers teaching science and mathematics at the secondary school will continue to be male teachers who have little patience with the girls and whose attitude towards the ability of girls to learn mathematics is negative. Secondly, as long as the girls do not see and interact with women scientists, they will for ever feel that science is not for women.

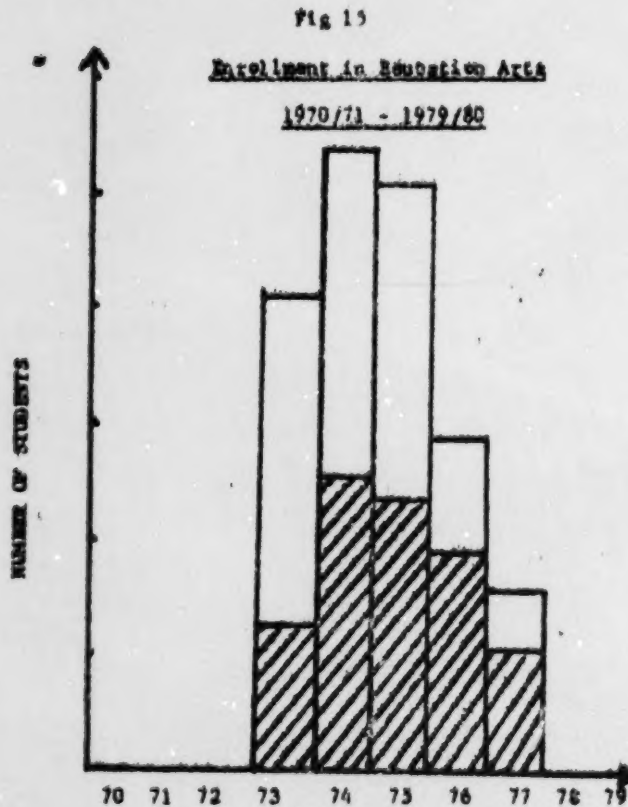
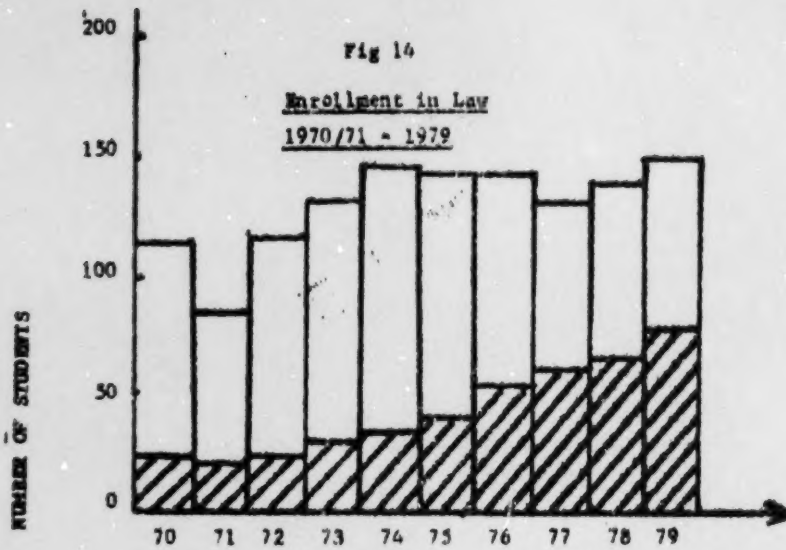


Fig. 16

Enrollment in Education Sciences - 1970/71 - 1978/80

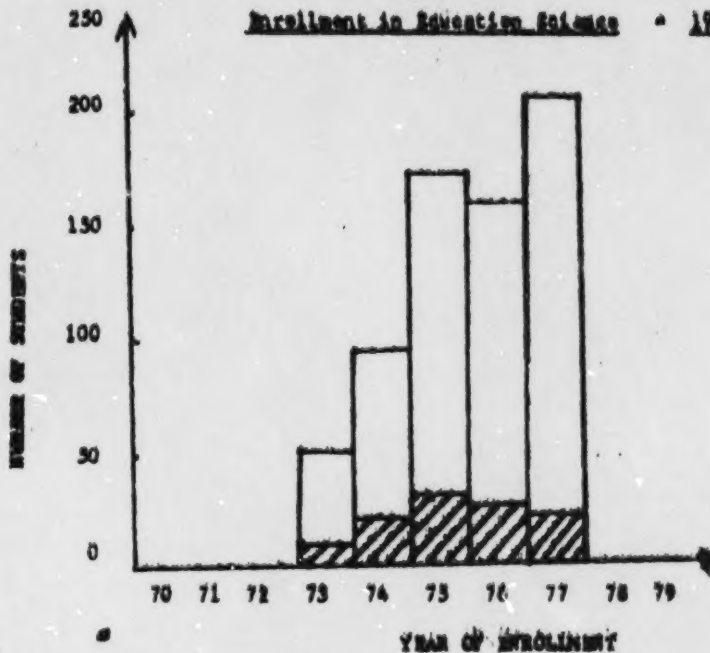
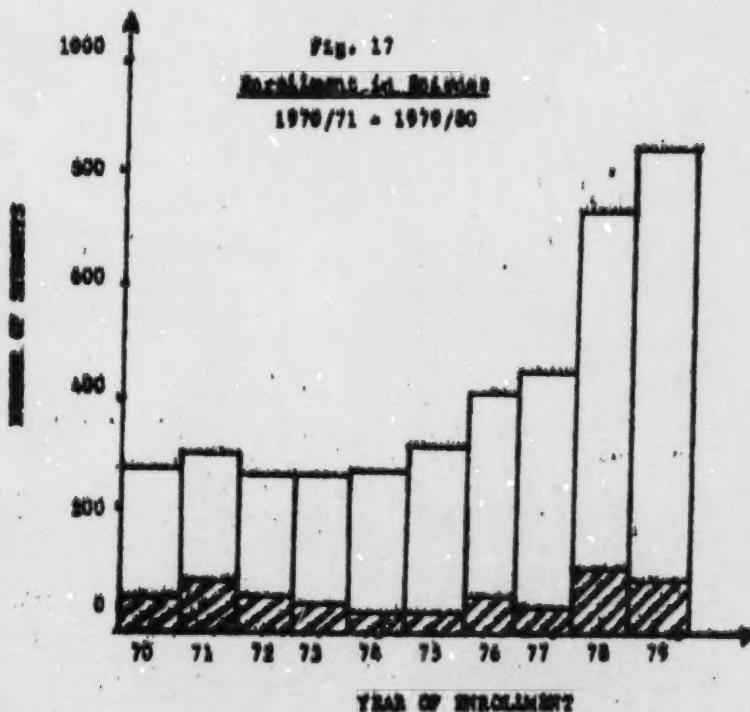


Fig. 17

Enrollment in Sciences
1970/71 - 1978/80



(1) Female Enrolment in the Faculty of Science

This study was essentially about the access of women to higher education in science. It is therefore appropriate that we consider the female enrolment in the faculty of science in detail. The enrolment results in science will be a pointer to the true position in other science related fields. Figure 17 shows the student enrolment in the Faculty of Science for the years 1970 to 1980. While there was a gradual rise in the number of male students from 1970 to 1976, there was a significant decrease in the number of female students during the same period; the lowest proportion of female students occurred in 1975/76 when they accounted for only 10.6 per cent of the total number of science students. During the second part of the 1970 decade there was a significant increase in the number of students studying science. Their number rose from 400 students to over 800 students. During the same period the number of female students enrolled in the Faculty hardly rose above 100 students. In 1979 when the total number of science students was 948, only 11.1 per cent were women.

The data for 1974 to 1980 is broken down into separate academic years in Figure 18. Two conclusions can be drawn from this data. First, female students are hopelessly under represented in the Faculty of Science. Secondly, the drop-out rate among the enrolled female students in the Faculty of Science is very high compared to that of male students. From some of the information we gathered, there were two major reasons for this significant differences both in numbers and performance between female students and male students in the Faculty of Science. First, the science background of the female students at the University was inferior to the background of the male counterparts. We found that generally speaking boys' schools which offer A-level science have better facilities comparable to girls' schools. The Boys' schools also tended to have better qualified teachers than the Girls' schools and the staff transfer incidence was much lower. This means that male students studying science at A-level had superior preparation to that received by their female counterparts. These observations will be discussed in more details in later paragraphs.

SUMMARY AND RECOMMENDATION

The results of this study agree with the data reported by Krystall (1973) that women are under-represented in the University education and especially in faculties which require science combination for admission.

The under-representation in science may be explained in part by the fact that these combinations are available at three-quarters of the boys schools with Forms V and VI, but at only 40 per cent of the girls schools. Increased provision of mixed schools at Forms V and VI seems to be one of the ways of increasing science opportunities for women. However, this strategy cannot guarantee quality science education for girls. For this reason other intervention strategies should be proposed. I recommend an immediate implementation on a pilot basis of compensatory enrolments for women in science fields both at University and at other post-secondary training institutions. One year of remedial instruction at University for women science students who achieve low at Form VI level would go a long way in closing the gap between the number of men and women studying science and related fields. The fact that relatively few women attain higher levels of education and training in science related fields contributes to the lack of science opportunities for girls at lower educational levels and to girls' tendency to avoid science subjects. One way to break this cycle is through special programmes designed to assist women to receive advanced training in science. In this connection I recommend strongly that a ~~Senior~~ School for girls specialising in science and mathematics should be established. Such a school could be run like a Junior College with a high concentration of well qualified teachers and facilities. International Agencies as well as Women Organizations could be approached for financial assistance in establishing such a school. This point will be discussed in greater detail later in this report.

5.1.4 Female Drop-Out from the Formal Education System

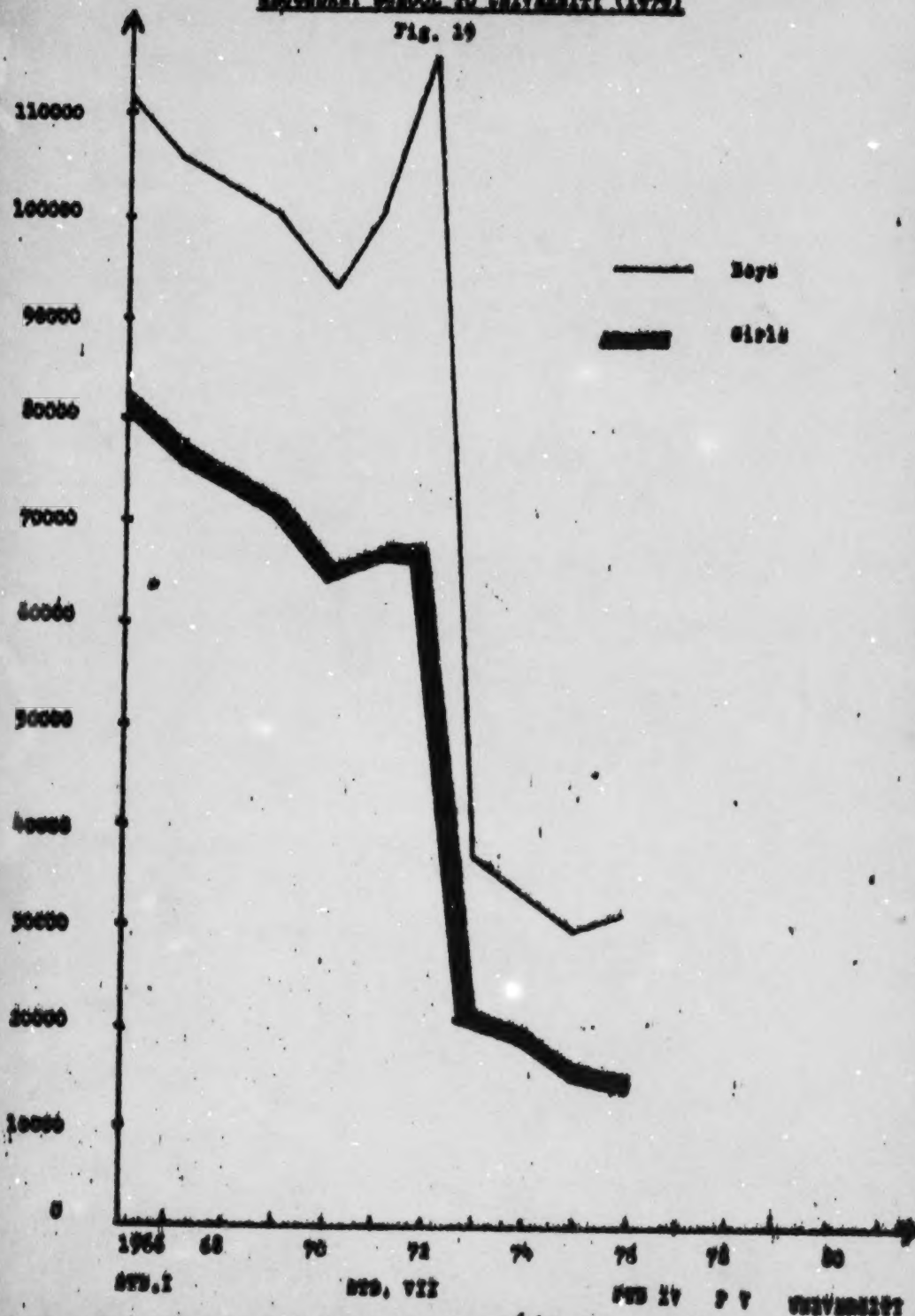
An important question that must be considered along side that of access is the rate at which the educational system retains those who enrol in it. In this connection we analysed the flow rates of five generations of students by sex starting from 1963 to 1967. The 1967 generation was the one that entered the University in 1960. Because the pattern of the data was almost identical for the five generations it was decided to restrict our discussion in this report to the 1966 - 1977 generation.

Figure 19 shows the number of students who enrolled in Standard One in 1966 and worked through the education system to the University in 1979. Several inferences can be made from the flow chart in Figure 16 with respect to female drop-out:

FLOW RATE OF STUDENTS FROM STD. 1 (1966) THROUGH

SECONDARY SCHOOL TO UNIVERSITY (1979)

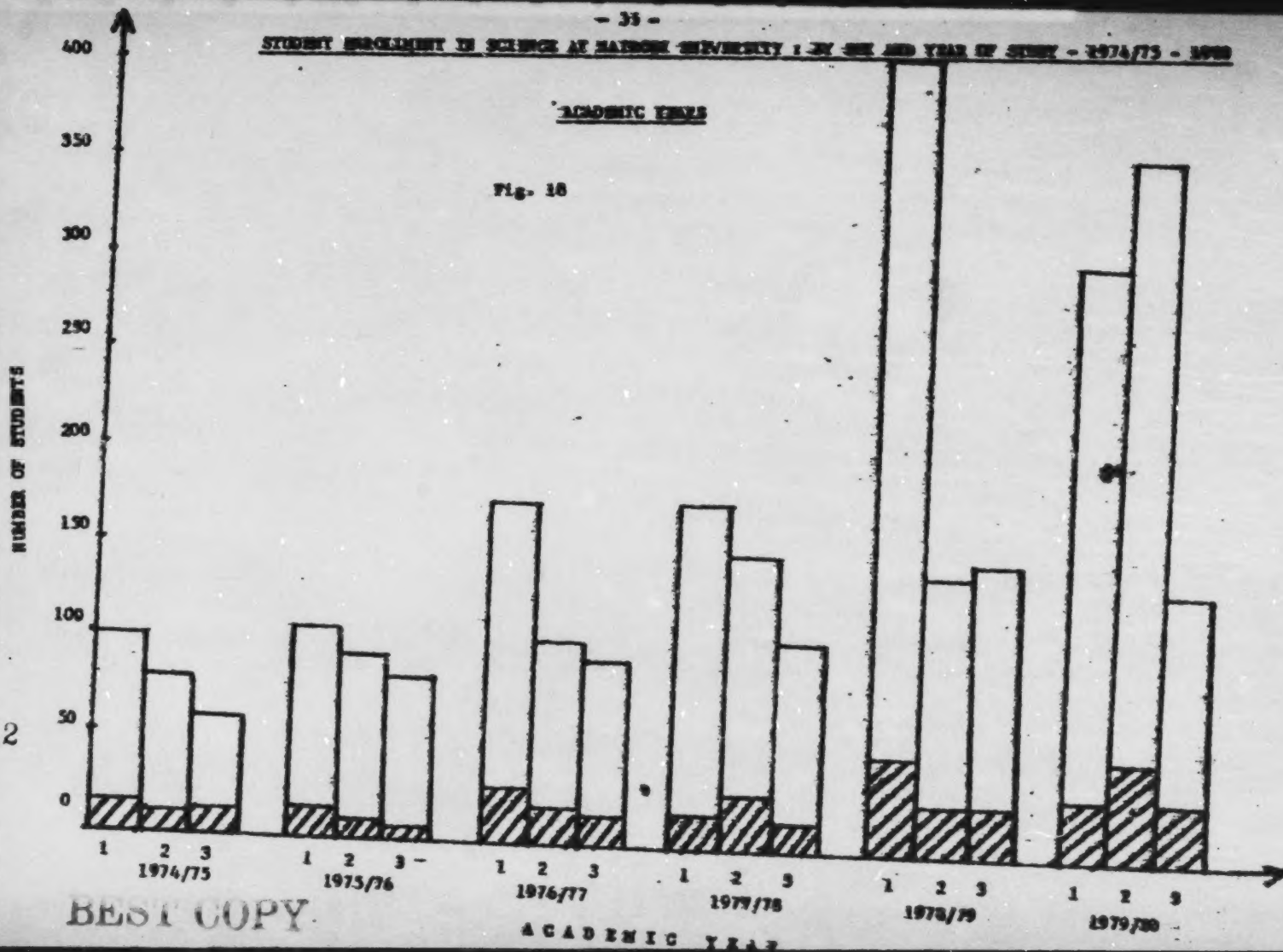
Fig. 19



STUDENT ENROLLMENT IN SCIENCE AT HAIKONG UNIVERSITY : BY SEM AND YEAR OF STUDY - 1974/75 - 1979/80

ACADEMIC YEARS

Fig. 18



- (a) In terms of retention, a slightly higher proportion of girls than boys now remains in primary school. However, the number of boys increases significantly at Standard 7 level, suggesting that girls who do not pass the Certificate of Primary Education tend to drop out of the educational system, but boys who do not pass CPE tend to repeat.
- (b) Female wastage is estimated to be at least three times the male wastage rate at primary level. Between 1966-1972 the percentage wastage among girls in the primary school was 26 per cent compared to 7 per cent among boys. It should however be noted that the actual wastage rate for boys could be much higher if the high number of boys who repeat especially in Standard Six and in Standard Seven were to be taken into account.
- (c) Based on data for 1972 only, CPE eliminates 71 per cent of the girls who sit compared to 67 per cent of the boys who sit. Several factors appear to contribute to this higher female wastage at the CPE level. The higher proportion of male repeaters gives boys an advantage over girls. In addition, girls at primary school tend to have a lower sense of competence compared to boys and have limited ambition for higher education. These characteristics could be products of the school system which overtly favours boys especially in subjects like mathematics. Furthermore, greater demands are made on female children to assist with household chores, to care for younger siblings and fetch firewood and water, and this work may interfere with schooling and depress female performance at the primary level.
- (d) The proportion of girls entering Form I has risen steadily. This proportion for the years 1968, 1972 and 1976 was 27.8 per cent, 33.7 per cent and 40.5 per cent respectively. However, by the time a class enters Form I, approximately 76 per cent of the girls who entered Standard I have been eliminated from the formal educational system compared to only 66% of the boys who entered Standard I at the same time. The performance of girls at CPE seems to account for only some of this difference.
- (e) Between Forms I and IV a greater proportion of girls than boys drop out of the educational system. Thirty five per cent of the girls who entered Form I in 1973 were lost to the system by the time their class entered Form IV in 1976 as compared to 21 per cent of the boys. Among the many factors that contribute to this high drop-out rate among girls at the secondary school level pregnancy is a major factor. Interview with a few Headmistresses revealed that over 10 per cent of female students are lost from the secondary school system every year through pregnancies. To arrest this wastage the practice of forcing a pregnant girl to terminate her education without providing other avenues of mobility should be reconsidered.

Sex education that has a component of formal and informal education, shared between teachers, the Family Planning Association and elders within the communities where the schools are placed should be introduced as soon as possible.

(f) The average percentage of female wastage in secondary schools between 1970 and 1980 was 31% compared to 17% for boys in Forms I-IV, and 5 per cent for girls and 3 per cent for boys in Forms V-IV respectively.

5.2 Sex differences in science examinations

5.2.1 Curricula Differences

The secondary school curriculum in Kenya has been influenced by a tradition of subject specialisation by pupils from Form III upwards, and shaped by an examination system that relies entirely on external assessment. The curriculum structure is shown in Figure 20.

In the first two years of secondary school all pupils are taught more or less the same subjects: Mathematics, English Language, Literature in English, Geography and History. In addition to these subjects, schools have the option to teach subjects from the following areas: in Humanities - Kiswahili, Christian Religious Education, Commerce and Islamic Christian Education; in Science - General Science, Physical Science, Physics with Chemistry, Physics, Chemistry, Biology, and Agriculture; in Culture - Music, Art, and Home Science. School options depend on the availability of staff and facilities. In the schools that we visited in the course of our investigation we found that a significant number of girls shy away from the science options. Many girls' schools offer biology and/or general science and no other science options. This means that science education does not receive as much emphasis in the girls' schools as other subjects during the first two years of the secondary school.

In the third year, most secondary schools operate some form of compulsory subjects. These subjects are usually English, Mathematics, a language (e.g. Kiswahili), a Science subject (e.g. Biology), and Social Studies (e.g. History). The compulsory subjects are supplemented by choices from groups of other subjects. It is at this stage that pupils encounter real options in the subjects they have to study. At this very early age the children are channelled into either Science streams or Arts streams. The choices these children make structure their later educational careers. To what extent are they aware of the implications of their decisions? We examined one implication of these decisions by looking at the number of boys and girls who sit for the Kenya Certificate Examination (O-level) in all subjects.

		HUMANITIES				SCIENCE SUBJECTS						CULTURAL & SOCIAL SUBJECTS		
		Maths	Litt in English	Kiswahili	Christian RE	Gen. Sc.	Physical Science	OPTIONS				OPTIONS		
Year 1	English Language		Geog.	Hist.	Islamic RE	Phys with Chem		Physics	SSP Pysc.	SSP Chem	SSP Biol	Agr.	Home Music, Sc.	Technical Subjects
Year 2					Commerce				Chem.	Biol	Human Biol	Art	OPTIONS	Business Studies
Year 3			OPTIONS (Pupils intending to drop Science choose subjects in this group)				OPTIONS (Pupils intending to pursue Science choose subjects in this group)					OPTIONS	OPTIONS	
Year 4		*	*	*	*	*	*	*	*	*	*	*	*	*
Year 5			Subject combinations in A-level Arts courses				Subject combinations in A-level Science classes							
Year 6			Eng Lit	Geog	RE	RE	Math	Pysc.	Geog	Math	Pysc.	Geog.		
			Geog	Econ.	Sw.	Sw.	Pysc	Chem.	Math	Biol				
			Hist.	Math	Geog	Hist	Chem	Biol	Biol					
			*	*	*	*	*	*	*	*	*	*	*	*

FIGURE 20

Secondary School Curriculum Structure in Kenya

*Public Examinations KCE and KACE

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TABLE VII
ENTRIES BY BOYS AND GIRLS IN KCE C-LEVEL EXAMINATIONS
IN 1981

Subject	Number		Percentage per sex*	
	Boys	Girls	Boys	Girls
English	15450	9185	100.	100
Mathematics	15268	9168	98.8	99.8
Physics	3409	455	22.1	4.9
Chemistry	3878	1204	25.1	13.1
Biology	12961	8394	83.9	91.4
Physics with Chemistry	4974	2538	32.2	27.6
General Science	1393	581	9.0	6.3
Literature in English	7751	7299	50.1	79.5
Christian Religious Education	8388	6920	54.3	75.3
Islamic Religious Education	127	11	-	-
Kiswahili Language	2090	4010	13.5	11.0
Kiswahili Literature	10932	5596	70.7	60.9
History	6709	4699	43.4	51.2
Geography	14594	8148	94.4	88.7

*Since English and Mathematics are compulsory the number shown for English is assumed to be the total number of all boys and girls and used as the unit for the calculations.

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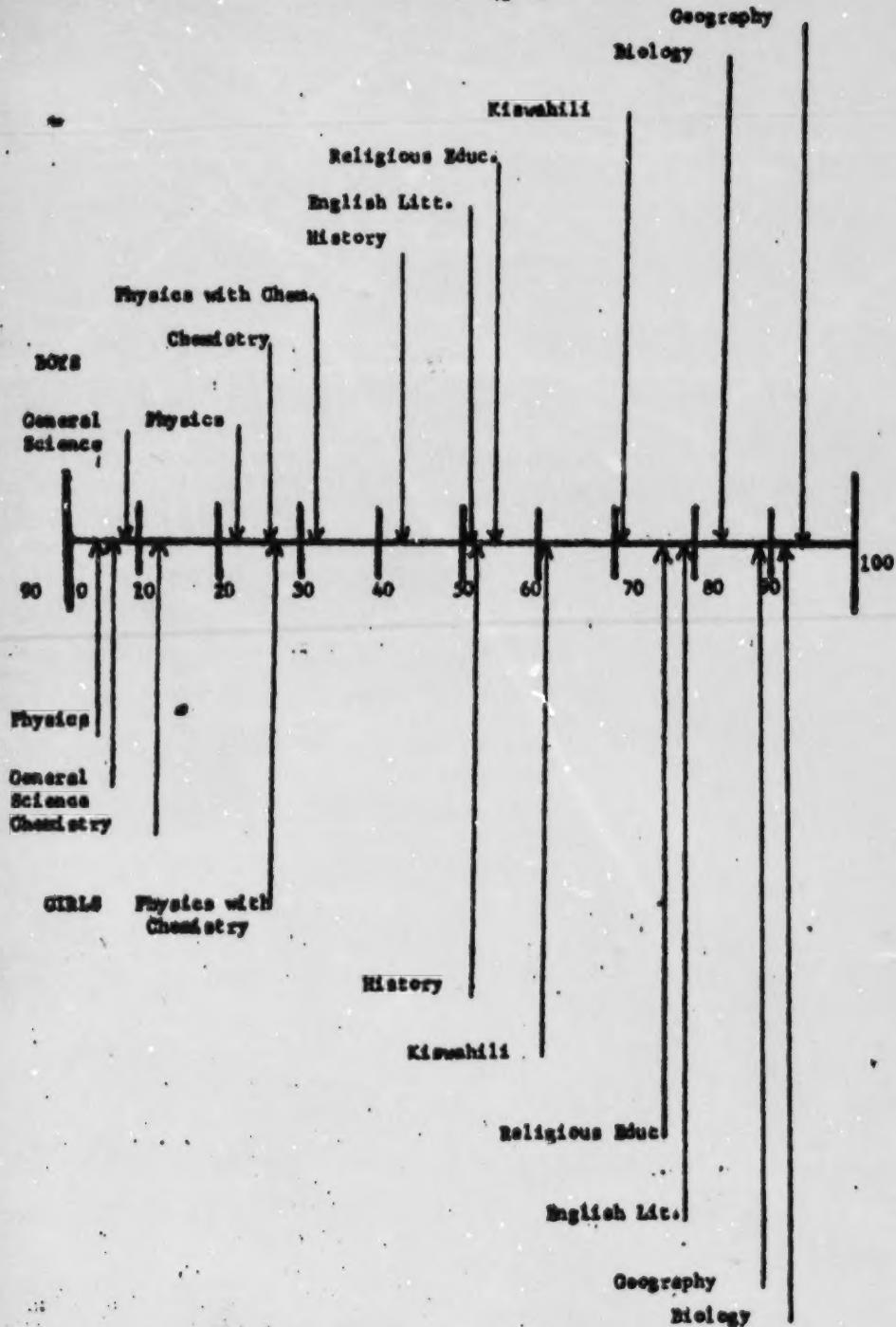


Fig. 21. Subject Choices by Boys and Girls at Secondary School.

The second conclusion that can be drawn from the science enrolments in Kenya is that a greater proportion of boys than girls study science at all levels of the educational system. This is not unusual result except that the differences in the numbers between boys and girls are enormous. In 1981 out of 9186 girls only 455 studied Physics in Forms III and IV compared to 3409 boys; the number of boys who enrolled for Chemistry and for Physics with Chemistry was twice the number of girls. This implies that the number of girls achieving any sort of grounding in the physical sciences is significantly small. Biology presents a more encouraging picture. The proportion of girls who enrolled for Biology was 91.4 per cent compared to 83.9 per cent for boys.

To find out why girls preferred biology to the physical sciences we interviewed: eight undergraduate students studying for a B.Ed. degree in Science at Kenyatta University College, eight Form Six students (girls) and five secondary school teachers. The interviewees seemed to agree on several points:

- (a) Biology is an easier subject for girls because "it is straight forward".
- (b) Physical sciences are difficult for girls because of the mathematical demands in science subjects.

5.2.2 Differences in Achievement

In this study eight subjects were chosen from the 1981 Kenya Certificate of Education Examination for detailed analysis. These were: English, Mathematics, Physics, Chemistry, Biology, Physics with Chemistry, History and Geography. The sample of candidates consisted of students from stable secondary schools (defined in this study as schools with Form VI status). Within this sample, schools were classified by "intake" (whether single - sex or mixed).

Table VIII shows the percentage pass rate for each subgroup in each subject. To gain further insight into the significance of differences between boys and girls, the results were categorised into four subdivisions, namely, Distinction (A), Credit (B), Pass (C) and Fail (D).

It is evident from the results in Table VIII that the achievement of girls in English is much superior to that of boys. At the distinction and credit levels, girls in Girls' schools perform significantly better than girls in Mixed schools and boys in both types of schools. This observation is consistent with other findings in previous research by Sheikh (1976) and Eshiwani (1974).

An interesting pattern can be observed in the mathematics results. There are significant differences between boys and girls - especially at the Distinction and Credit Levels. While 4.2 per cent of the boys in boys' schools received a distinction only 1.6 per cent of the girls in girls' schools and 0.5 per cent of girls in mixed schools received the same grade. At the credit level, the ratio of boys to girls in single-sex schools was 5:1 while in mixed schools it was 3:2. In single-sex schools 42.1 per cent of boys failed their mathematics examination compared to 61.8 per cent of girls. Performance in mixed schools was generally worse than that of single-sex schools.

We have already noted that less than 5 per cent of girls offer Physics in the Kenya Certificate Examination. We analysed their performance in comparison to boys' performance and in two curricula (the Nuffield-based SSP Physics and the "traditional" Physics). At credit and distinction levels boys achieved higher than girls in both curricula. However, there was a marked improvement in the SSP Physics by girls reducing the differences between the two sexes significantly. While in the "traditional" Physics 16% of girls in the Girls' schools and 25.2% of girls in mixed schools obtained a credit/distinction, in the SSP Physics 32.6 % of girls in Girls' schools and 9% of girls in mixed schools obtained the same grade. At Pass level a higher percentage of girls passed in the SSP Physics than in the traditional physics. This result has a pedagogical implication in the teaching of Physics to girls. The SSP Physics emphasizes the practical approach in which the pupils "find out" by themselves. It does seem that this approach is more successful with girls than the teacher-centred approach that is often found in the "traditional" Physics. Analysis of performance by girls in the SSP Chemistry and SSP Biology does not lend support to the generalization of the above statement. In fact a greater proportion of girls failed the SSP Chemistry and SSP Biology than those who failed "traditional" Chemistry and Biology. In the "traditional" chemistry and biology there were no significant differences in the performance between boys and girls.

TABLE VIII
PERCENTAGE PASSES FOR BOYS AND GIRLS BY INTAKE AND
EXAMINATION GRADE:

THE KENYA CERTIFICATE OF EDUCATION 1981

Subject	Grade	Girls in Girls Schools	Boys in Boys Schools	Girls in Mixed Schools	Boys in Mixed Schools
English	A	3.2	1.6	0.7	0.6
	B	35.2	30.0	19.3	16.8
	C	38.1	37.9	30.2	29.2
	D	23.5	30.5	49.8	52.2
Mathematics	A	1.6	4.2	0.5	2.4
	B	5.9	30.7	8.7	16.6
	C	20.7	23.0	12.1	17.3
	D	61.8	42.1	78.7	63.7
"Traditional" Physics	A	0.3	2.9	1.5	1.9
	B	15.7	33.7	23.7	42.4
	C	31.5	23.7	34.4	27.7
	D	52.5	33.5	40.5	27.7
SSP Physics	A	0.2	4.1	0	0
	B	32.4	39.5	9.0	26.1
	C	35.4	32.2	42.4	39.5
	D	31.8	24.0	46.4	34.2
SSP Chemistry	A	1.4	7.0	0	1.4
	B	38.0	39.7	13.7	34.7
	C	32.7	25.3	20.6	35.4
	D	27.1	27.8	65.5	28.3

Subject	Grade	Girls in Girls Schools	Boys in Boys Schools	Girls in Mixed Schools	Boys in Mixed Schools
SSP	A	1.1	2.7	0.3	2.5
	B	20.6	35.9	11.6	35.5
	C	29.4	31.9	38.8	37.2
	D	48.6	29.3	49.1	24.5
"Traditional" Chemistry	A	2.9	3.8	3.9	11.4
	B	34.3	38.7	35.7	44.0
	C	34.3	29.4	32.4	26.5
	D	28.4	27.9	27.9	17.8
Biology	A	1.2	1.6	0.2	0.5
	B	27.2	41.5	15.5	27.0
	C	35.0	33.0	12.5	35.6
	D	36.4	23.8	71.6	36.6
Physics with Chemistry	A	0	4.6	0	3.8
	B	10.3	29.2	7.1	13.4
	C	27.2	30.7	20.0	26.9
	D	62.3	35.3	72.8	55.7
Geography	A	2.5	6.3	0.3	1.9
	B	43.5	52.7	23.5	31.4
	C	20.1	19.5	42.3	20.3
	D	33.9	21.5	33.9	44.4
History	A	1.9	1.5	0.5	0.6
	B	27.8	27.6	13.9	14.6
	C	43.7	28.9	27.52	34.7
	D	26.5	41.7	58.0	49.9

In Physics-with-Chemistry, the boys' performance is far superior to the girls' performance. No single girl obtained a distinction! The proportion of girls who failed was twice that of boys. This statistic shows the general weakness of girls in the physical sciences.

There is a general assumption among educators that girls perform better than boys in the Arts subjects. To find out if this was true we analysed the performance of girls and boys at O-level in Geography and History. In Geography boys in single-sex schools performed better than girls in both girls' schools and in mixed schools. However girls in mixed schools performed better than their male counterparts by a percentage difference of 10.9%. This pattern is reversed in the history results. Girls in single-sex schools outshine boys although boys in mixed schools perform better than their female counterparts.

In summary, then, this analysis of science enrolments and achievement in Kenya has shown that more boys than girls study science at secondary school level. The ratio of boys to girls entering for O-level Physics is 8:1; in Chemistry it is 3:1; in Physics with Chemistry it is 2:1 and in Biology it is 3:2. Secondly, research into boys' and girls' performance in O-level science examination, described in the above paragraphs, reveals a significant difference in success in terms of percentage passes in science and mathematics. This difference is in favour of boys. However, girls in single-sex schools appear to perform better than the corresponding groups of boys and girls in mixed schools. These results suggest that any intervention strategy for the improvement of science education among girls should steer clear of co-education.

Further analysis of the examination results in mathematics and science subjects is reported in Table IX. A difference of five percentiles between boys and girls was considered significant. Based on these results, we found that there was a significant overall difference between percentage passes for boys and girls in mathematics, biology, and in physics. There was no significant difference between boys and girls in chemistry and in physics with chemistry.

The second point that is evident from this analysis is that single-sex schools perform significantly better than mixed schools in mathematics, biology and in physics with chemistry. But interestingly enough, pupils in mixed schools perform significantly better than those in single-sex schools in physics and boys in mixed schools perform better than boys in single-sex schools in chemistry.

There is no significant difference in the percentage passes between girls in mixed schools and those in single-sex schools. Clearly there is some contradiction concerning the effects of type of school.

TABLE IX
PERCENTAGE PASSES FOR BOYS AND GIRLS BY TYPE OF SCHOOL AND
BY SUBJECT (MATHEMATICS AND SCIENCE SUBJECTS ONLY) IN THE
1951 EXAMINATION

	Boys	Girls
Mathematics		
All Schools	50.8	33.3
Mixed Schools	36.3	21.2
Single-sex Schools	57.9	38.2
Biology		
All Schools	72.4	54.5
Mixed Schools	63.4	28.4
Single-sex Schools	76.2	63.6
Physics		
All Schools	68.0	51.0
Mixed Schools	72.3	59.5
Single-sex Schools	66.5	47.5
Chemistry		
All Schools	74.0	71.7
Mixed Schools	82.2	72.1
Single-sex Schools	72.1	71.6
Physics with Chemistry		
All Schools	76.9	75.1
Mixed Schools	44.3	27.2
Single-sex Schools	64.7	37.7

Notes:

- > Boys do better than girls by at least 5 percentiles
- ✓ Co-educated pupils do better than single-sex educated by at least 5 percentiles
- ^ Single-sex educated pupils do better than co-educated by at least 5 percentiles.

5.3. Why girls fail in Science and Mathematics?

It is evident from the data reported in the previous paragraph that, 'overall' boys achieve better than girls in science and mathematics in the Kenya Certificate of Education. One of the main objectives of my study was to explore the reasons for this sex difference. As previously stated, these reasons are generally grouped into two broad categories: 'biological' and 'environmental' factors. In my study I was mainly concerned with the latter group of factors.

Biological explanations of sex differences in science achievement have been studied extensively in the Western countries during the last ten years. Gray (1981) has suggested that sex differences in science achievement is "the result of a genetically based sex difference in spatial ability". Maccoby and Jacklin (1975) and Saraga (1975) have defined spatial ability as "that ability to perceive relations in space and visualize objects in three dimensions". They have argued that this ability is crucial to mathematical skills, which in turn are crucial to science especially the physical sciences. Several psychologists, sociologists and educationists subscribe to this view (Byrne, 1978; Witkin, 1968; and Weiver, 1980). Bryden (1979) has advanced the explanation that sex difference in spatial ability is due to the fact that cerebral organization of men and women is somewhat different. Buffery and Gray (1972) call this phenomenon, "brain lateralization". They argue that there exists a dichotomy between linguistic and spatial skills in the hemispheres of the brain (linguistic skills in the left hemisphere and spatial skills in the right); the left side of the brain develops earlier in girls giving them their relative linguistic superiority whereas boys' develop later and retain a right-side cerebral dominance giving them greater competence in spatial-related activities. This explanation for sex differences in science and mathematics has been challenged by Rose (1979), Riley (1978), Fennema and Sherman (1977). There seems to be no conclusive evidence that there is undisputable relationship between cerebral organization and achievement in science and mathematics.

In the following paragraphs we will discuss the environmental explanations for sex differences on the basis of data collected in this study.

There are three main hypotheses that will guide us in our discussion. They centre on the following factors: students' previous achievement (at primary school level), students' social background, students' attitudes towards science and mathematics, teachers, school practices and policies, parents, and students' self-confidence. The hypotheses are:-

- (1) The school provides different treatment and experiences for boys and girls in science and mathematics and sows the seeds of differential achievement. This may be described as the school hypothesis.
- (2) Girls achieve less than boys because they have less favourable attitudes towards science and mathematics, and have little aspiration for science-based careers.
- (3) Girls do not achieve as well as boys in science and mathematics because society expects them to under-achieve in these subjects. This may simply be described as the socio-cultural hypothesis.

5.3.1 School Factors:

Conventional wisdom has placed the blame for under-achievement in science and mathematics among girls at the door-step of girls' schools with their assumed poor level of provision of laboratories, equipment and staffing. It can be argued that if these assertions were true, then we would expect the performance of boys and girls in co-education schools to be the same. The results in this study show that a greater proportion of girls in single-sex schools choose to study science and achieve better than their counterparts in mixed schools. This does not however prove that school factors do not make a difference in achievement between boys and girls.

In this study five major school factors were considered: sex-role stereotyping, pupils' previous academic achievement, instructional methods, facilities and teachers.

(a) Sex-role Stereotyping:

Sex-role stereotyping is perhaps the most subtle and perhaps the most significant factor in the differential academic achievement between boys and girls. In the co-educational schools it occurs at a much higher level than in single-sex schools.

Through "hidden curriculum" schools bring social pressures to bear upon boys and girls to conform to masculine and feminine characteristics - respectively. Boys are expected to be "active, aggressive, dominant, objective and interested in ideas"; girls are expected to be "passive, nurturant, subjective and more interested in people than in ideas". One evidence of sex-role stereotyping that I came across in the course of this study was the belief among University female students that "a woman cannot study mathematics and/or science and be beautiful at the same time". Another piece of evidence on this phenomenon is the DES Education Survey in England which noted that (1975):

"..... in the primary school, despite the lack of distinction made between the sexes in curriculum, there were subtle differences in the teaching of boys and girls, that the sexes behaved differently, but that more importantly, they were expected to behave differently by their teachers".

In the co-education schools stereotyping occurs through the classroom interaction between teachers and pupils and through classroom organization.

Other major school factors that I considered in this study were: performance at primary school level, teaching methods, staffing and school facilities for teaching science and mathematics in girls' schools. We will now discuss each one of these factors with a view to determine if they make a difference in achievement between boys and girls in science and mathematics.

(b) Past Academic Experience:

If two sexes enter secondary school with different academic background it is by no means obvious that the same treatment will have the same effect on them. In fact such a treatment may widen rather than narrow the existing differences. It was with this consideration in mind that I analysed the performance of primary school pupils in the Certificate of Primary Education (CPE) in the rural schools in 1980 and 1981 respectively. The CPE results for boys and girls for these two years are represented in Table X.

It is evident from the data in Table X that in general boys perform better than girls in all subjects.

TABLE X
MEAN PERCENTAGE SCORES FOR BOYS AND GIRLS IN THE
CERTIFICATE OF PRIMARY EDUCATION 1980 AND 1981*

Subject	Mean 1981			Scores 1980		
	Boys	Girls	Gap	Boys	Girls	Gap
English	48.92%	43.60%	5.32%	44.9%	41.9%	3.0%
Science	43.53%	37.30%	6.23%	48.3%	42.4%	5.9%
History	43.84%	38.36%	5.48%	43.3%	36.4%	6.9%
Geography	47.72%	40.96%	6.76%	45.6%	37.2%	8.4%
Mathematics	44.22%	37.36%	7.84%	40.9%	40.5%	0.4%

*Source: Kenya Examinations Council: CPE Newsletter 1983, P 19

In 1980, the highest sex differences were observed in mathematics and in geography. In 1981, the highest difference was observed in mathematics and science. This implies that boys and girls enter secondary school with different academic background, especially in mathematics and science (geography is regarded here as a science subject). At secondary school both sexes follow a common curriculum and presumably taught in the same way. The result is that most girls end up by dropping science (and they would do the same for mathematics if it were not compulsory) and those who continue with it achieve less than boys. The secondary school can therefore be blamed for under-achievement in science and mathematics among girls because in its operation, it builds upon a foundation of knowledge and experience which is present for boys but absent for girls.

(c) Teaching Methods:

The effects of teachers' instructional style upon learning outcomes and attitudes of students in mathematics and science is not well-researched. No attempt was made to study this question directly. However, the data on achievement in subjects where different instructional styles were employed leads one to speculate that the teaching methods employed to teach boys and girls make a difference in achievement.

In Table XI we have the percentage passes for boys and girls in: Physics and SSP Physics, Chemistry and SSP Chemistry, Biology and SSP Biology respectively. The SSP curriculum was adapted from the Nuffield Curriculum of the 1970s and emphasizes practical work and the discovery approach. Parallel to the SSP curriculum is the "traditional" curriculum in Physics, Chemistry and Biology which emphasizes theory and in which the instructional approach is largely expository. Examination of the data in Table XI indicates that the instructional styles employed in the SSP curricula and in the non-SSP curricula seems to make a difference in the achievement of boys and girls.

TABLE XI
PERCENTAGE PASSES IN SCIENCE SUBJECTS IN WHICH DIFFERENT
INSTRUCTIONAL APPROACHES WERE USED

Subject	Percentage Pass		per type of school	
	Girls Schools	Boys Schools	Mixed Girls	Schools Boys
Physics	47.5	66.5	59.5	72.3
SSP Physics	68.2	70.0	51.6	65.6
Chemistry	71.6	72.1	72.1	62.2
SSP Chemistry	72.9	72.2	34.5	71.7
Biology	63.6	76.2	28.4	63.4
SSP Biology	51.4	70.7	50.9	75.5

An earlier study by Eshiwani (1975) observed that teaching methods make a difference in performance among girls. He compared the effectiveness of three instructional methods in the teaching of probability to Form II pupils. The methods were: Programmed Instruction (PI), Integrated Programmed Instruction (IPI) and Conventional Classroom Instruction (CCI). He found that girls taught through the PI method achieved higher than the other two groups. It was also noted that when compared to boys, girls who were taught probability through the PI method performed as well as boys taught by the same method. Although it is dangerous to generalise from this study, it would seem that academic achievement among boys and girls is affected by the methods used in teaching them, especially in mathematics. The human teacher was found to be generally prejudiced against girls and their ability to learn mathematics.

Kelly (1961) has said that 'teachers should not assume that methods which are successful with boys will automatically be successful with girls, but should be sensitive to sex differences in inter-personal relationship'. In our interviews with Sixth Form girls studying science we were told that they liked working in groups during science classes (mainly laboratory classes) and that they preferred teachers who emphasized the practical applications of science. The girls said that they disliked teachers who belittled them concerning their ability to learn science. These findings indicate to us that certain adjustments should be considered, both in the training of teachers and in their employment in the classroom. Kenya needs teachers who are both competent in science and who do not show negative attitudes towards the ability of women to learn science.

(d) Teaching Staff

The quality of teachers is an important variable in pupils' academic achievement. For this reason we carried out a comparison of the strength and quality of teachers in twenty boys' schools and twenty girls' schools all with Sixth Form Science classes. The boys' schools had 257 male teachers (87.1%) and 38 female teachers (12.9%) making a total of 295 teachers. The girls' schools had 128 male teachers (53.1%) and 113 female teachers (46.9%). Thus there are more teachers in the boys' schools than in the girls' schools.

Majority of the teachers in both boys' schools and in the girls' schools were relatively young - they were below 35 years of age. We found no major differences between the qualifications of the teachers in the boys' schools and in the girls' schools. This means that most senior girls' schools have well qualified and experienced teachers. However, we found one major difference between boys' schools and girls' schools with regard to the way the teachers were allocated their teaching duties. While in the boys' schools qualified and experienced teachers were used in the years one and two, in the girls' schools this was not the case. This means that the girls were given a poor impression of science at an early stage of their secondary education.

Science teachers in general were not involved in out-of-class activities. This was more evident in the girls' schools than in the boys' schools. This does not improve the image of science teachers in the eyes of the girls. Indeed, one Arts undergraduate we interviewed told us that she opted out science at the end of Form IV because it tends to develop negative personal relationships.

* If girls are to be encouraged to study science there should be evidence to show that their predecessors who took science have succeeded as well as men in their careers. For this reason we analysed:

(a) the proportion of women science teachers in the boys' schools as well as in the girls' schools and

(b) the number of women science teachers who had been promoted to the position of heads of science/mathematics departments, deputy heads or head teachers.

The ratio of women to men teachers was 0.46 in the girls' schools and 0.13 in the boys' schools. To put it another way less than 30 per cent of mathematics and science teachers are women. In more than two thirds of the schools we visited, the heads or their deputies were non-scientists. Of course in the girls' schools the heads were female teachers, but when it came to heads in science and mathematics departments, more than 80% of the heads were men, even in the girls' schools. /the

Teachers have a potential as role models. It is therefore imperative that the number of women science and mathematics teachers in girls' schools should be increased. We compared levels of promotion of male science teachers and female science teachers who had graduated at the same time. We found that while most of the male teachers had become heads of departments or schools within four years of their graduation, it took some of the female teachers ten years to attain the same level. This point may have some effect on the number of girls at school who decide to read science.

(e) Laboratories:

Laboratory accommodation in most senior girls' schools was satisfactory in quantity and quality. However when compared to those in the boys' schools laboratories and equipment in the girls' schools were poor. We compared two national schools - a boys' school and a girls' school. While the boys' school had five laboratories the girls' school had only two laboratories. The equipment in the boys' school was adequate and new while in the girls' school the equipment was generally inferior and inadequate. The situation was so bad in one girls' school that a Sixth Form Science class had to be run down by the Ministry of Higher Education. Surprisingly there was no outcry from the women groups on this closure. The majority of girls' schools which do not have Form Six classes experience severe shortage of laboratory accommodation. This threatens the position of girls in science.

5.3.2. Attitudinal Factors:

It is generally believed that girls perform less well than boys in science because girls have less favourable attitudes towards science. Other related factors include: self-confidence, career interests - expectations and counselling. We will discuss these factors separately.

(a) Attitude toward science and mathematics

Although some research has been done in Kenya on the attitudes of secondary school students towards mathematics (Eshiwani, 1974; Kibanza, 1982 e.t.c) there has been no research on the attitudes of students towards science. Research on attitudes towards mathematics has shown that in general girls tend to have negative attitudes towards mathematics and this tends to affect their performance.

In this study we gave an attitude questionnaire on science to girls in Form Six. Table XII summarises this data. It is evident from the data that girls regard science to be more difficult than any other subject. This implies that when given curriculum options they would drop science subjects. Interesting enough most of the girls did not think that science is too hard to understand, neither do they find it boring. They enjoy it (presumably when it is well taught) and more than 50 per cent of them would like to continue studying it. This last statistic could be deceptive because the 6s who responded to this questionnaire were mainly science majors.

TABLE XII
ATTITUDES TOWARDS SCIENCE

STATEMENT	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Parents think science is very important	27.1	49.4	13.4	4.6
2. Science is easier than other subjects	8.0	10.2	38.8	32.9
3. Science is more difficult than other subjects	11.2	19.1	42.2	23.6
4. Students good in science are looked up to	24.3	36.6	22.1	13.0
5. Science is hard to understand	10.8	17.7	37.4	29.9
6. Science is easier for me than any other subject	7.8	15.2	42.8	29.6
7. One cannot get along perfectly without science	13.6	18.2	41.3	22.7
8. I would like science if it weren't so hard	19.5	38.5	25.3	10.6
9. The subject I enjoy least is science	11.2	19.0	33.6	30.1
10. Science is boring	8.0	10.8	35.5	35.7
11. No matter how hard I try I can't understand science	6.7	13.2	39.4	34.8
12. I would like to study more science	28.3	29.4	23.8	14.3

In our interview with girls in Forms III and IV we found that most of them regarded science to be difficult. They took unduly pessimistic view of their own potential.

(b) Self-confidence

Several studies show that one of the reasons why high school students may not do well in mathematics is lack of self-confidence. Numerous studies e.g. (Fox, 1977; Sherman, 1979) have reported sex differences in self-confidence with respect to achievement in mathematics. The extreme lack of self-confidence, often termed mathematics anxiety or methemaphobia was found to exist more among the girls than boys in this study.

In science we found that girls lacked confidence in themselves for laboratory work. Most of them had not developed practical interests of a scientific and technological kind. For example, most girls we interviewed in Form V could not change a fuse nor could they connect electrical wires to a battery for fear that they would be electrocuted. There seems to be a need for compensatory training in practical work to minimise the anxiety girls have in both mathematics and science.

(c) Carrer aspirations and expectations

One of the dominant factors influencing subject choices (and achievement) is career aspirations and expectations. In our questionnaire we asked the girls the question: What would you like to be ten years from now? Table XIII shows the responses of the girls for different careers. The top five jobs that were aspired for by the girls were: journalism (53.8%), university teaching (48.9%), business (35.3%), teaching (35.1%) and law (35.1%). None of these professions require science or mathematics. The proportion of girls who said that they did not wish to join those professions which required science was alarming: engineering (70.1%), dentistry (64.7%), agriculture (50.5%). When they were asked which faculty at university they would choose first if they had the opportunity to go to the university only 1.1 per cent of the girls chose engineering, 1.5 per cent chose architecture, 1.9 per cent chose veterinary science, 7.4 per cent chose agriculture while 14.3 per cent chose medicine.

TABLE XIII
WHAT KENYAN FEMALE STUDENTS WOULD LIKE TO BE TEN
YEARS FROM NOW

	VERY MUCH	NOT SO MUCH	NOT AT ALL	CAN'T SAY
1. I would like to be a doctor	15.2	20.3	56.5	--
2. I would like to be a politician	12.0	33.1	52.6	1.5
3. I would like to be a business woman	35.3	40.7	14.9	1.1
4. I would like to be a teacher	35.1	44.3	18.2	0.4
5. I would like to be a lawyer	35.1	31.4	32.7	0.4
6. I would like to be a farmer	21.2	52.2	26.0	0.6
7. I would like to be a full-time house-wife	4.5	30.5	64.1	0.9
8. I would like to be a nurse	9.3	39.2	50.7	0.7
9. I would like to be an engineer	8.2	20.6	70.1	1.1
10. I would like to be a secretary	7.1	36.8	55.8	0.4
11. I would like to be a chemist	16.9	25.5	56.5	1.1
12. I would like to be a dentist	9.3	25.5	64.7	0.6
13. I would like to be an agriculturalist	13.0	29.6	56.5	0.9
14. I would like to be a university professor	48.9	31.2	19.7	0.2
15. I would like to be a journalist	53.8	35.5	29.6	1.1

16. I do not know what I would like to be : YES 16.5%
NO 76.0%

These statistics can only mean one thing: guidance and counselling in the scientific and technical fields is an area that girls' schools have not paid much attention to. It is mainly for this reason that girls do not express interest in careers of a scientific or technical nature. Most of the girls in Form VI had only a limited knowledge of the opportunities in higher education outside academic disciplines and medical courses. To counteract this problem we commend that girls' schools start a carefully structured guidance services in science education for pupils in Form III upwards. One period or two periods should be set aside on the time-table in which science teachers can give talks, arrange for discussions on the market value for scientific qualifications, and invite speakers from university departments and from industry. At a higher level the university should have "open days" in which senior students from the schools can be provided with the opportunity to meet the staff of various science departments and related faculties, for them to hear at first hand the courses available. We believe that such personal contacts could make a major impact on the girls' choice of science.

In towns where there is a wide-range of science based industries, schools should be encouraged to take their students there for visits and to secure vocational jobs for the girls during the holidays.

The girls' expectations in the academic attainment was very high: 29.7 per cent and they said that they wanted to get Ph. D., 29.6 per cent wanted to get Masters degree while 37.8 per cent wanted to get First degrees. Given the fact that the University of Nairobi can hardly admit 15 per cent of those girls who qualify for admission, our Ss were clearly unrealistic in their expectations.

Some of the girls we interviewed told us that one of the factors that influenced them to study or not to study science was the advice given by parents as well as by the school. Table XIV shows the level of encouragement given by parents, teachers and peers to the girls to study science.

TABLE XIV
LEVEL OF ENCOURAGEMENT GIVEN TO GIRLS TO STUDY SCIENCE
BY VARIOUS GROUPS OF PEOPLE

	Encouraged Very much (Per cent)	Discouraged Very much (Per cent)	Not Reported (Per cent)
Men Science Teachers	18.8	56.5	24.7
Women Science Teachers	30.7	43.1	26.2
Fathers	7.1	73.6	19.1
Mothers	59.3	24.7	24.7
Peers	33.6	45.4	21.0
Biology Teachers	67.1	21.4	-
Mathematics Teachers	17.1	63.6	19.0
Physics Teachers	30.3	43.7	25.8
Chemistry Teachers	20.4	56.7	22.9
.....			
Who influenced you most to major in science?	Job opportunities in scientific/ technical fields		22.7%
	Parents		3.0%
	Science Teachers		4.3%

It is evident from the data in Table XIV that in general more men science teachers (73.0%) discourage girls to learn science than female teachers (43.1%). When it comes to individual subjects, the mathematics teachers are the worst in discouraging girls from learning mathematics. In general we found that most mathematics teachers (male and female) did not expect girls to perform well in mathematics. This has caused the so-called "Pygmalion effect" in education, according to which the girls perform in response to the expectation of the teachers. At least 64 per cent of the secondary school mathematics teachers do not expect female students to do well in mathematics. In chemistry more than half of the teachers (56.7%) discourage girls from studying the subject.

The percentage of teachers who encourage the girls to go on with Physics is 30.3 per cent. This is a small proportion compared to 67.1 per cent of the biology teachers who encourage the girls to study biology. No wonder, there are more girls enrolled in the biology classes and biology related classes than those enrolled in the physics classes.

The most intriguing result is the percentage of fathers and mothers who encourage girls to study science subjects. Only 7.1 per cent of the fathers encourage their daughters to study science compared to 59.3 per cent of the mothers. In fact over 70 per cent of the fathers do not think that their daughters should meddle with science.

Fellow students seem to have had a considerable influence on the girls' choice of science. One third of the girls told us that they were influenced to choose science by their peers.

As discussed earlier job opportunities do influence girls to choose to study science. Slightly over 20 per cent of the girls told us that they chose to study science because of job opportunities in the scientific fields.

5.3.3. The Socio-cultural Factors

In section 5.1 we noted that one of the reasons why women are under-represented in the formal education sector is the traditional view about the proper role of women in society. In this respect there are two conflicting attitudes towards the education of girls: one, that girls should receive an education equal to that of their brothers; the other, each ... sex should be educated to fit the role it assumes in society. Although official pronouncements and the school curriculum favour the view of equality of education for both sexes, the reality is that the Kenyan society subscribes to an education whose major goal is to prepare girls to be good home-makers, wives and mothers. The 'ideology' of educating girls to fit the role expected of them by the society is evident during schools' Speech days at the end of the school year. I analysed five such speeches given in five senior girls' schools at the end of 1981. The central theme seemed to be that the education the girls had received was important not so much for their careers but for home-making.

This point of view cannot receive much support on its face value. However, when examined in the context of what happens in science education among girls, it immediately becomes apparent that society does not expect girls to 'waste' time on subjects that are irrelevant to their future expected roles. Science is viewed by many people, especially males, to be irrelevant to home-making. It is for this reason that we found that over 70 per cent of fathers in Kenya discourage their daughters from pursuing science education and science-related occupations. There seems to be an underlying assumption among these fathers (and others) that there is a conflict between being a good scientist and a good home-maker. We did not have time to examine this hypothesis in this study.

The evidence we gathered suggested that under-achieving in science education among girls was largely due to societal expectations. The argument goes like this: the society does not expect girls to achieve high in science; because of this the aspirations of girls are reduced and consequently achieve low in their science examinations. This proposition, although attractive, is not convincing. If the argument given above was valid then we would expect girls to perform poorly in all science subjects. The fact that this is not the case implies that there are other factors, apart from societal expectations that are responsible for under-achievement in science education. However, we can state with certainty from our data that societal expectations have a significant influence on the girls' decision whether or not to study science.

I will now examine the extent to which the social background of the girls influences the choice of science and achievement in it by girls.

Previous research on the relationship between social background and academic achievement seem to indicate that students' background has some effect on their general performance levels (James and Pafford, 1973; Husen, 1972; Eshiwani, 1977). I examined this relationship for girls studying science in Forms V and VI.

I used the family related variables, such as socio-economic status, parental education and parental attitude towards education as indices of social background.

Other social variables such as ethnicity, religion, and geographical location of the Ss were not considered. Before we discuss the results we obtained, I would like to sound two warnings: First, the socio-economic-status is a very difficult variable to categorise especially in Africa. This may be in part due to non-existent or distinct classes in Africa. Where classes exist, they may not necessarily be based on socio-economic status. They may be based on political orientation or on a multiplicity of other diffuse variable. Secondly, any study of the social background of students can only be regarded as an overall descriptive picture of the students. It cannot tell us how a particular child from a particular social stratum is treated by his or her parents or what kind of psychological processes are acting as barriers, against success in education. Husen (1972) has stated that most of the social background variables are distal and not proximal indices of how social background actually works.

The first variable we examined in relation to girls studying science and arts was parental education. Table XV shows that in general there was no significant difference between the levels of education of parents of girls who were studying science and those who were studying arts. It is interesting to note that in either case 50 per cent of the fathers and mothers of the Ss had an education of upper primary and above. This implies that girls who are likely to receive higher education in Kenya are likely to come from families in which one or both parents have received at least upper primary education.

The second variable that we examined was the occupation of the parents of the female students. Table XVI shows that there was a significant difference between the occupations of the parents of girls taking science and the occupations of the girls taking arts ($P < .001$). Considering each occupation we noted that there was no difference between arts students and science students from farming background but there was a difference between girls whose parents were working in the wage employment sector. Girls whose parents were Clerks or Executives tended to take arts subjects while girls whose parents were either teachers or senior officers (but non-executives) tended to take science subjects. One explanation for this is that clerical work and most of administrative work (often the mainstay of executives) does not require much science. It is conceivable that parents holding these positions will encourage their daughters to follow their footsteps.

TABLE XV
PARENTAL EDUCATION OF SCIENCE AND ARTS FEMALE
STUDENTS (PER CENT)

		No Schooling	Lower Primary Std 1-4	Upper Primary Std 5-8	Secondary School	Univer- sity
Father	Arts	6.2	14.3	31.1	34.7	9.8
	Science	7.2	17.1	27.6	33.7	9.9
Mother	Arts	14.8	25.6	35.6	18.5	2.8
	Science	20.4	23.2	27.8	22.1	1.7

Chi square = 11.3005 df = 8 Significance = 0.1649

TABLE XVI
PARENTAL OCCUPATION OF SCIENCE AND ARTS FEMALE
STUDENTS (PER CENT)

	Peasant Farmer	Large Scale Farmer	Teacher	Clerical Officer	Non- Exec- utive	Execu- tive	Other
Arts	25.8	4.8	10.9	6.2	4.5	12.9	34.8
Science	26.5	4.4	12.7	2.8	11.6	3.9	47.1

Chi square = 27.7834 df = 8 Significance = 0.001

TABLE XVII
SOURCE OF SCHOOL FEES AMONG SCIENCE AND ARTS
FEMALE STUDENTS (PER CENT)

	Produce from Shamba	Family's Shop	Father's Salary	Mother's Salary	Brother's or Sister's Salary	Uncle or other relatives
Arts	23.8	5.3	51.8	5.9	7.6	1.7
Science	18.8	3.3	47.0	2.6	11.6	0.6

Chi square = 31.7362 df = 8 Significance = 0.001

TABLE XVIII
THE BIRTH ORDER OF SCIENCE AND ARTS FEMALE STUDENTS
(PER CENT)

	First Born	Second Born	Third Born	Fourth Born	Fifth Born
Arts	17.9	18.8	13.7	13.7	12.0
Science	22.1	20.4	11.0	11.6	11.0

Chi square = 5.3501 df = 2 Significance = 0.6173

TABLE XIX
NUMBER OF BROTHERS AND SISTERS WHO HAVE COMPLETED FORM IV
AMONG SCIENCE AND ARTS FEMALE STUDENTS (PER CENT)

	B R O T H E R S						
	0	1	2	3	4	5	6
Arts	16.0	20.4	21.8	14.8	9.5	7.6	4.8
Science	19.3	18.8	17.1	10.5	10.5	12.7	3.3

	S I S T E R S						
Arts	46.8	26.6	12.0	7.8	3.4	0.8	1.7
Science	46.8	24.3	15.5	5.5	3.3	2.8	1.7

On the other hand, the non-executives are perhaps technicians and technologists at various levels. They are likely to encourage their daughters to study science and pursue science-related careers.

The third family variable that we examined concerned the main source of school fees. Table XVII shows that the sources of school fees for science and arts female students.

Our results show that there is a significant difference between the sources of school fees between science students and arts students. While science students obtained their school fees from all the sources mentioned, the arts students obtained a much higher proportion from the same sources. For example, while 51.8% of arts students obtained their fees from their fathers' salaries, only 47.0% of the science students obtained their fees from the same source. It is interesting that a higher proportion of brothers and sisters paid fees for girls studying science than those studying arts. This is despite the fact that there was no significant difference between the arts students and the science students with respect to the number of brothers and sisters who had completed Form IV as of the time of this study (see Table XIX).

The fourth and final family variable we examined in relation to choosing science and arts was the birth order of our Ss. Table XVIII shows that there is no significant difference between the birth order of arts female students and science female students. However, the data shows that in general the first and second born females are likely to study science while the third, fourth and fifth borns are likely to study arts subjects. This observation needs further investigation.

6. Conclusions and Recommendations

This study has shown that in general women are under-represented in education in Kenya at all levels but especially in the higher education. Most important, the study has shown that women in Kenya are under-represented and under-achieve in science and mathematics education. This result has far-reaching implications on the employment of women in the science-related and technical fields. It has a dampening effect on the proponents of women's rights especially in the area of equality to education. The study reinforces the view that the reasons for girls' choice of science subjects (or avoidance of them) at school and failure in them are complex. I have suggested that the most powerful forces contributing to the low attainment among females in science and mathematics education in Kenya are to be found within the school, within the home and within the society. I have also suggested that the way the school curriculum is structured, its content and methods influences the number of girls who choose to study science and those who fail to achieve well in it.

I will try to use the research results that have been presented in preceding sections to suggest intervention strategies as well as steps that might be taken to increase girls' participation in science education. Most of the recommendations revolve round the secondary school because I believe that this is a critical level in science education.

Recommendation 1: More Secondary Schools for girls

Because of the evidence that there are fewer secondary schools for girls than boys, special effort should be made to open more Government maintained girls secondary schools. These schools should be non-co-educational and boarding.

Recommendation 2 : Girls' Technical Schools

Technical education in Kenya is dominated by male students. This situation is not based on any empirical data that says that girls cannot achieve in technical education. In the future planning of educational programmes, especially at the secondary school level, technical education should be introduced in the girls schools. In the same way technical schools exist for boys, there should be technical schools (on experimental basis first) for girls.

Recommendation 3 : A model science academy for girls

Science education has not received much encouragement in the existing schools among girls. There is a need to create one or two model secondary schools that have a strong bias towards science. Such model schools might be a beginning of greater participation in science education by girls in Kenya and indeed in Africa. Special effort should be made to attract donor agencies in the support of such schools.

Recommendation 4 : Compensatory Enrolment

Enrolment at the University is strictly based on performance in the A-level examinations. The results of this study show that girls are disadvantaged when it comes to science education. They have a poor background for science. One way of getting around this problem is to introduce compensatory admission for women in the science faculty and related faculties at university and other tertiary levels. One year of remedial instruction at university for women science students who have achieved low at A level would go a long way in raising the number of women scientists in Kenya.

At other institutions such as the Kenya Science Teachers' College where the proportion of women students is 20 per cent special provision should be made to ensure that women desiring to study science or science-related subjects are encouraged to make up for any deficiencies they may have in the subjects they wish to study. Similarly, in the schools remedial classes should be set up for girls to compensate for any deficiencies in their theoretical or practical work. Such classes may help the girls to gain confidence in science and to overcome their fear for science and mathematics.

Recommendation 5 : Drop-out Rates

Attrition rates among girls at all levels of education are very high. Pregnancy is one major factor contributing to this attrition. The factor can no longer be ignored in Kenya's educational system. There seems to be a need for a new policy on how to rehabilitate girls that get pregnant while at school so that they could continue with their education in some way. It should be understood that by making this recommendation, one is not condemning unwanted pregnancies, especially among the teenage girls.

Recommendation 6 : Curriculum Structure

The curriculum structure that is operational in the schools today encourages specialization at a very early age though its optional system. This has encouraged a great proportion of girls to drop science as early as in the first year of secondary school. For these girls, there is no hope for them to study science again. We recommend that science should be part of every child's educational experience. Specialization must be delayed and the value of a broad education encouraged. A more balanced curriculum should be encouraged in all secondary schools, including girls' schools.

Recommendation 7 : Lack of Confidence in practical work

One of the reasons given by girls for their lack of interest in science was their lack of confidence in handling equipment, tools and materials. This lack of confidence can be traced back to the primary school. It is recommended that a common course for boys and girls in the upper primary should be offered in craft subjects.

This will help to widen the practical experiences of girls, even at the primary school level.

Recommendation 8 : Instructional Styles

Instructional methods employed in teaching science and mathematics may influence the learning and achievement of girls in these subjects. The results of this study indicated that in general girls prefer 'pupil-centred' approach as opposed to 'teacher-centred' approach; they liked science classes in which they worked in groups and in which the teachers were well organised and disciplined. These findings suggest that certain adjustments should be considered, both in the training of school teachers and in their employment in the classroom. Teacher Education Institutions should be made aware of the plight of girls in science and mathematics education in order to help prospective teachers evolve appropriate instructional methods in the girls schools.

Practical work is a major attraction in science classes among girls, especially in Forms II and III. Over-theoretical approach involving intensive note-taking is not liked by the girls.

There is an urgent need for school-based inservice training and discussion on the problems faced by girls in science and mathematics.

Recommendation 9 : Role Models - Teachers

Role models play an important role in education. If a young girl never encounters a woman scientist or a woman mathematician, she will take it for granted that science and mathematics are not for women. She will harbour these thoughts irrespective of whether she has the ability and the opportunity to study these subjects or not. In our interviews with university students, we were told by some of the Ss that their interest to study science subjects or mathematics was accelerated when they came into contact with either a woman scientist or a woman mathematician.

We recommend that every effort should be made to post the best women teachers in science and mathematics in the girls' schools. At the moment most of these women teachers are in the boys' schools where they have no role model to play. The proportion of women in most science departments in the girls' schools was significantly small.

This led to the feeling among girls that science, and especially physical science, were men's subjects. If more women teachers were employed to teach the e subjects in the girls' schools, it might help more girls to realise that the physical sciences are just as much for females as they are for males.

Secondly, there is a need to promote women scientists into positions of responsibility such as heading schools and departments. This may have a significant influence on the girls in choosing to study science and mathematics.

Recommendation 10: Laboratory Accommodation

Laboratory accommodation is an important input in pupils' achievement in science. In the majority of the girls' schools we visited, the laboratory space and equipment was unsatisfactory in quantity and quality. In some schools science was taught in classrooms and in one school a Sixth Form Science stream was run down because there was no laboratory accommodation for the girls! Evidence from the boys' schools indicated that they had adequate laboratories as opposed to the girls' schools which seemed to have been designed with the assumption that many girls will opt out of physical sciences. Every effort should be made to correct this situation.

It should be noted that the appearance of laboratories has an effect on the attitude of girls towards science.

Recommendation 11 : Guidance and Counselling

Career guidance and advice in relation to science and mathematics was found to be almost non-existent in most girls' schools. Most careers 'masters' in these schools were ignorant of career opportunities in scientific and technical fields, market combinations of subjects or higher education course requirements, except in the more traditional university faculties such as medicine and engineering. The schools hardly invited speakers from the university or from the industry with a background in science fields. Because of this, most girls including those in Form Six had only a limited knowledge of career opportunities in science and technical fields.

We recommend that science teachers in the girls' schools and careers 'masters' should be assisted to become more aware of opportunities in science-based and technical fields.

A symposium for these teachers should be planned for in the near future. Some of the questions that might be discussed in such a symposium might include:

- (a) What career opportunities are opened up or closed when a student drops certain science subjects?
- (b) In what way can schools communicate with the parents on the subject choices of their daughters? What critical information do the parents need?

Secondly, all science departments in the schools should be directly involved in the guidance and counselling of girls in Form Three. People with industrial background should be invited to talk to the girls. There would be no harm to set aside one period of 40 minutes every week in which the girls discuss careers involving science.

At a higher level the Ministries of Higher Education and Labour, and the Women's Bureau may help by printing pamphlets on science-related careers for schools.

Recommendation 12 : Concept formation in science and mathematics

In recommendation 8 we discussed instructional styles and how they influence girls' performance in science and mathematics. Related to this is the way concepts are introduced to girls, especially in science. We found that in the physical sciences there is a very high mathematical demand on the girls. Secondly, some of the science subjects including mathematics were too abstract and theoretical. For most girls (and boys) this approach is counter-productive. There seems to be a need for changes in the science and mathematics curriculum to de-emphasize abstractness and factual over-loading. Such changes must inevitably lead to changes in the examination. The way examinations in science are set pushes schools to rush through syllabuses at a hectic pace, giving the students little time to understand what they have learned. The students are given inadequate time for practical work. The emphasis is on passive note-taking and learning, both of which have a negative effect on the students' learning, especially among the girls. If more girls are to be encouraged to study science and mathematics then both science and mathematics curriculum and examinations should be reviewed - in reference to the issues discussed above.

It should be pointed out that elaborate changes in curriculum and examinations can be introduced and have no effect if the teachers do not translate them into action. In this connection we recommend that senior, experienced teachers should teach the lower classes of the secondary school. They are in a better position to know when they should introduce different scientific or mathematical concepts to students better than younger, inexperienced teachers.



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